THREE ESSAYS ON HUMAN CAPITAL, MIGRATION AND RURAL DEVELOPMENT IN DEVELOPING COUNTRIES

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Submitted to the faculty of the University Graduate School
in partial fulfillment of the requirements
for the degree Doctor of Philosophy
in the Department of Economics,
Indiana University

July 2010

Accepted by the Graduate Faculty, Indiana University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Date of Oral Examination: June 11, 2010

To my father Min Liu, my mother Liangjiao Yu, and Chouchou

Acknowledgements

I would like to thank my advisor Gerhard Glomm, who is, in my opinion, the most fabulous advisor anyone would ever want to have, and I cannot thank him enough for guiding me through the process of writing my dissertation. Professor Glomm has influenced me tremendously in research, teaching and attitude toward life. He has read numerous drafts of my dissertation and was always quick to respond with valuable feedbacks. Over the past three years, Professor Glomm has always been patient with me and trusts that I can do it. He is like a father and role model to me, both rigorous and encouraging, giving me unfailing support of my work.

I am grateful to my dissertation committee members Michael Kaganovich, Pravin Trivedi, and Rubiana Chamarbagwala.

I first knew Professor Michael Kaganovich in my first year graduate course. He is a wonderful teacher, wise and humorous. We had many conversations about my dissertation and I have learned a lot from his strictness as a mathematician and creativeness as an economist. Aside from economics, Professor Kaganovich is very logical and strategic—the very merits that I admire and aim to possess.

Professor Pravin Trivedi is not only a world-class econometrician, as many have known, but also an unbelievably personable and humble scholar. I received invaluable advice from him on my empirical paper in my dissertation. From our very first meeting, I knew that I was in good hands. He was always so kind that I dared to raise even the most trivial questions. If I need to use one word to describe Professor Trivedi, I will choose "encyclopedia". He can give references on papers published many years ago in various academic journals, which is an ability that impresses many students in Indiana University.

I would also like to thank my other professors at Indiana University—Bob Becker, Edward Buffie, Fwu-Ranq Chang, Eric Leeper, Brian Peterson, Konstantin Tyurin, James Self, Paul Graf, and Willard Witte—for their classes, suggestion and recommendations.

I would like to give my heartfelt thanks to staff members in the economics department at Indiana University, especially Chris Cunningham. She is the first person I met in the economics department upon arrival. Over the past five year, she has always been there for me and shared the joy of my every little success. She is the most elegant, precise, gentle, and hardworking lady I have ever seen.

I would like to thank Indiana University for giving me the great opportunity, without which, I would not have come to the United States, I would not have received excellent education from this top university, and I would not have obtained my PhD in economics and become a college professor.

From the deepest part of my heart, I would like to thank my parents. My father Min Liu and my mother Liangjiao Yu are the best parents one can ever ask for. They visited me in US for my graduation. Knowing only "Yes" and "No", my parents enjoyed their "talk" with staff in grocery stores using body language, while other foreign visiting parents avoiding shopping alone. I think, or at least I hope, that I inherited their spirit of curiosity, persistence and exploration. Knowing that they are always there cheering for me, I am confident to face any challenges and realize all my dreams.

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THREE ESSAYS ON HUMAN CAPITAL, MIGRATION AND RURAL DEVELOPMENT IN DEVELOPING COUNTRIES

Abstract: This dissertation studies several important issues in developing countries. The first essay focuses on rural-urban migration and rural entrepreneurship in China. I find that depending on the initial human capital level, policies aiming to advance human capital may have different impacts on migration. Even though return migrants help raise rural labor demand and wages, the income inequality between the urban and rural areas is not eliminated and migration is persistent. The borrowing constraints limit the size of rural non-farm businesses and slow down the development of the rural industry. The second essay studies the dynamics of rural-urban migration income and rural non-farm business ownership in China, applying a dynamic bivariate probit model to the China Rural Households Survey Data. The positive correlation between receiving migration remittances in one period and operating rural non-farm business in the following period is explained by correlated unobserved heterogeneity. A negative state dependence between receiving migration remittances and operating rural non-farm businesses can be justified by the time and labor constraints facing rural households. The third essay provides a theoretical study of teacher absenteeism, a severe phenomenon in many less developed countries. I focus on several policies, such as labor taxes, financial penalties, and teachers' wage rate, to examine the short-run and long-run effects of these policies on teacher absenteeism, economic growth, goods production, and quality of lower and higher education.

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CHAPTER I

HUMAN CAPITAL, MIGRATION AND RURAL ENTREPRENEURSHIP IN CHINA

1.1 Introduction

This paper analyzes rural-urban migration and rural non-farm entrepreneurship in China. The migration from rural to urban area is induced by the prospect of higher income; meanwhile, high returns to human capital in rural non-farm business entice some migrants to return to the countryside and start as entrepreneurs. The migration to the cities and eventual return-migration is one instrument that circumvents credit constraints in rural China.

A thorough understanding of China's policies and background is necessary for the study of the migration phenomenon. China's transition from a central planning economy to a market economy began at the end of 1978. This economic reform has several important implications for the rural areas. First, the restrictions on rural-urban labor mobility was relaxed and migration to the urban area became possible for most rural agents. From the 1950s to the late 1970s, the rural-urban migration was prohibited by the Household Registration System, or the Hukou system. The Hukou system not only imposed strict controls on internal migration, but also prevented rural residents from accessing and obtaining many public services their urban counterparts received. The Hukou system effectively blocked upward social mobility for most rural citizens. During early 1980s, rural agricultural productivity improved tremendously, which resulted in a surplus of rural labor. In order to accommodate this labor supply pressure, the Chinese government implemented reforms for the Hukou system to promote the mobility of rural residents. Beginning in 1984, rural born individuals could obtain resident status in towns if they had employment and housing and could provide their own food rations (Chan and Zhang, 1999). As a result of the Hukou system reform, the urbanization in China leaped from 17% in 1978 to 24.52% in 1986 and to

42.99% in 2005. The Bureau of Statistics of China (BSC, 2004, 2006) estimated that there were 130 million migrants in 2003.

The second crucial implication of China's economic reform is on the rural non-farm sector. Prior to the reform in 1978, the rural development policy in China focused on agriculture. The rural non-farm sector only began to develop after the early 1980s (Mukherjee and Zhang, 2005). According to the National Bureau of Statistics of China, the share of non-farm sector employment in the total rural employment increased from zero in 1978 to 34% in 2002, and that of farm sector declined from 100% to 66%. Figure (1) presents the rural farm and non-farm employment from 1978 to 2002, and figure (2) shows the trends in relative terms. Even though the non-farm sector experienced fast growth in rural China after the reform, the rural financial market failed to show the same pace of development. Since the 1980s, there have been several government attempts to liberalize the financial system in rural China; however, the results have not met the expectations. The financial markets in the rural area largely differ from those in the urban area. While the latter have had modernization and even participated in global competition, the former are stagnant. Cheng (2004) and Guo (2009) both show the rural credit markets are fragmented so that formal credit programs are highly centralized, "cheap" credits are earmarked to certain agricultural investment, and private lending is strictly regulated and usually illegal. Deposits in rural China have been increasing over the past two decades; however, loans in those areas have not shown the similar growth. Figure (3) and table (3) illustrate the decline in the ratio of total rural loans to deposits from 1985 to 2004, which indicates that the rural loanable funds are either channeled outside of rural China or are left unused (Jia, 2007). Successful entrepreneurship calls for mature financial markets. Facing borrowing constraints, many potential entrepreneurial projects in rural areas rely heavily on self owned funds or borrowing from relatives and friends.

The growing migration and return migration have contributed to the development of rural non-farm sector. According to the China Rural Development Research Center, one third of migrants began returning to their rural homes in late 1990s. Murphy (2002) claims that return migrants owned one fifth of all private enterprises in surveyed counties. In

1996, the 4000 migrants returning to the county Yudu established around 1450 private and individual businesses involved in production or manufacturing. Out of all the new projects in the surveyed counties with annual product values of around one million yuan (0.12 million dollars), 63% were created by return migrants.

It is not a coincidence that return migrants are more likely to invest and enter rural non-farm entrepreneurship. Migrants have at least two advantages over non-migrants in starting own business. First, migrants generally have better education than non-migrants. Table (1) presents the summary statistics of non-migrants, migrants, and return migrants in a survey conducted by Ministry of Agriculture in 1999. The human capital of permanent migrants and return migrants appears to be higher than that of non-migrants, whereas there is no significant difference between permanent migrants and return migrants. Murphy(2002) also claims that migrants in her survey had higher human capital and better skills than non-migrants. Second, due to the higher income in cities, migrants have saved more than non-migrants. Facing borrowing constraint, the self owned funds are extremely crucial for rural agents to start businesses.

Two strands of literature are directly relevant for this paper. The first strand explores reasons for migration. Glomm (1992) specifies a model in which joint restrictions on technologies and preferences are the driving force of migration. Communication and learning are crucial for production, and such communication requires less time in the densely populated city than in the countryside. The resulting higher rate of growth in the city causes migration out of the countryside and into the city. Lucas (2004) views migration as a transfer of labor from a traditional, land-intensive technology to a human capital-intensive technology with an unending potential for growth. The desire of accumulating skills in cities is emphasized as the key motivation for migration. Liang, Chen and Gu (2002) implement an empirical study of the impact of rural industrialization on migration using data from the 1990 China Population Census. Their estimation results show that the rural industrialization does not have a statistically significant effect on the probability of migration.

A second strand of literature reaches to explain the phenomenon of return migration.

Dustmann (2003) introduces parental concerns for their children that may lead to an increase or a decrease in the tendency of migrants to return home. Zhao (2002) analyzes a household survey carried out in six provinces in 1999 and finds that return migration is of limited scale and out-migration is dominant. It shows that education and age both increase one's likelihood of returning; besides, people who are married and especially geographically separated from their spouse are more likely to return. Dustmann (1997) establishes a model where savings and migration durations are jointly determined. In his paper, the return of migrants is driven by the preference of consumption in the hometown. Other reasons for returning home after migration includes difficulty arising from urban congestion, high cost of living, housing cost, emotional preference of hometown over guest area, uncertainty of living in guest place, etc. While papers such as Dustmann (2003), Zhao (2002) and Dustmann (1997) explain the return migration by demographic and psychological reasons, other have done so by connecting the return migration with investment and entrepreneurship. Brauw and Rozelle (2003) show that migrants and return migrants have higher investment levels than non-migrant households during the time their data spanned. However, it turns out that the migrants' primary investment tool involves sending remittances to their families, which may only be used for the family production process. Ihahi (1999), using cross-sectional data from Pakistan, finds that return migrants exhibit a high tendency of choosing self-employment over wage employment. Mesnard (2004) evaluates how liquidity constraints affect self-employment of return migrants. The above three papers all relate return migration to entrepreneurship; however, they only focus on self-employment. Even though the size of new businesses established by return migrants in China is primarily small to medium as shown in table (2), only modeling self-employment will understate the role of return migrants in promoting local employment.

Two gaps in the literature thus emerge. First, out-migration and return migration are generally studied separately, which downplays the fact that both activities are part of the lifetime decision. Second, the entrepreneurship of return migrants is restricted to self-employment in the existing literature, which greatly simplifies the analysis, but the way of modeling overlooks the impact of return migrants on labor demand in the home market.

Different from the approaches taken in the literature, this paper examines the interactions among out-migration, return migration and rural entrepreneurship. In a two period overlapping generations model, combinations of migration and entrepreneurship choices when young and old categorize rural residents into four groups. Facing the borrowing constraints, rural individuals are not able to start businesses when young. Nonetheless, migration to cities offers an opportunity to accumulate enough capital to enter entrepreneurship when old. An agent who chose not to migrate when young remains in rural area when old. An agent who migrated in the early stage of life can either remain in the cities or return home later on. In this way, return migrants essentially channel credits from cities to their rural hometown. This framework accommodates the analysis on how and to what extent the return migrants contribute to employment and economic growth in the countryside.

After solving the model analytically, we calibrate it to China. Several main findings emerge: first, depending on the initial human capital level, policies aiming to advance human capital may have different impacts on the volume of permanent migrants. If the initial human capital level is low, the policies will yield more permanent migrants; on the contrary, if the initial human capital is at a relatively high level, then we can expect a shrinking permanent migrant class. Therefore, the fraction of permanent migrants exhibits an inverted U-shaped relation with the median human capital. Secondly, regardless of the initial human capital, there will be fewer non-migrants and more return entrepreneurs under policies improving human capital in rural areas. Thirdly, the equilibrium rural wage is higher when human capital improves, as a result of the decreasing supply and increasing demand of rural labor. Fourthly, on the balanced growth path, the rural wage rises at the same growth rate as the urban wage. Income of each occupation grows at the same constant rate. Lastly, the cost of migration hinders labor mobility. Some permanent migrants turn to either non-migrants job or become temporary migrants when migration cost surges. Costly migration accompanies fewer entrepreneurs and impairs rural wage.

The paper is organized as follows: section two introduces the model; section three defines the equilibrium; section four proves the existence of the stationary equilibrium; section five presents the simulation results; we conclude in section six. The appendix contains all figures and tables.

1.2 The Model

We use a two period over-lapping generations model to study one small rural area in a less developed country (LDC), such as China In this small open economy model, goods prices and interest rate are exogenous. The rural economy is populated by a continuum of individuals, who live for two periods. In their first period of life, they can either work in the farm sector, in the rural non-farm sector, or migrate to cities and work there. At the beginning of the second period of life, an individual has accumulated saving. These savings can either be deposited in the bank and earn interest, or invested in a rural non-farm entrepreneurial project and earn a profit. There are several reasons why a migrant wants to start a non-farm businesses in the rural but not the urban area: first, a minimum capital is required to launch an entrepreneurial project. It is reasonable to assume that this minimum requirement level is smaller in the less-industrialized area. Secondly, if there were complete credit markets, then individuals could just borrow against their future income in order to get over the initial capital requirement. However, this possibility is assumed away in this paper because of the common observation that it is very difficult for rural-origin migrants to obtain credits in urban area. This is related in China to decades of the 'identity control' of Household Registration System (HRS, or Hu Kou), and labor-personnel dossiers (Ren Shi Dang An) (Li, 1996). Hence, if a rural-origin individual has a plan for an entrepreneurial project, the capital input that he can command is solely from his own saving. An individual's own wealth has significant impact on the possibility of becoming an entrepreneur. Quadrini (1999) shows that a potential entrepreneurial project may fail to be launched if the household's net asset value is sufficiently low. Third, the urban area where competitive corporations have already settled at is more industrialized, hence strong competition crowds out the rural-origin, small businesses starters, who return to the rural area to look for businesses opportunities. This phenomenon has been noticed by China's government as well as economists and sociologists. For these three reasons, it is essential to model the entrepreneurial activities of rural migrants in the rural area.

Following Galor and Zeria (1993), individuals are assumed to only consume in their second period of life and derive utility from this consumption. Thus an individual who is born in period t has lifetime utility:

$$U = lnc_f + lnc_e + lnc_u. \tag{1.2.1}$$

Everyone derives utility from consumption of three types of goods: agricultural goods c_f produced by farms, and non-agricultural goods c_e produced in rural non-farm entrepreneurs' firms and c_u manufacturing goods produced by urban industry sector. We can think of c_f as rice, c_e as shoes, and c_u as TV sets. Since we are studying a small rural area in China, it's plausible to assume that prices for agricultural goods, c_f, non- agricultural goods c_e, and urban manufacturing goods c_u are all exogenous.

There are two types of production in the rural area: farm and non-farm. Farm production uses labor and land as inputs:

$$F^f(L_f) = A_f L_f^{1-\eta} Z_f^{\eta}, \tag{1.2.2}$$

where A_f is the agricultural productivity, and L_f is total labor input in farm sector, andZ_f is the total available agricultural land in the rural area.

The rural non-farm enterprises hire physical capital and labor to produce non-agricultural goods through the following production function:

$$F^e(k_e, l_e, h) = A_e h k_e^{\alpha} l_e^{\beta}, \qquad (\alpha + \beta) \in (0, 1), \tag{1.2.3}$$

where A_e is the total factor productivity level in rural non-farm sector, k_e is physical capital input, and l_e is labor input. Here h is this entrepreneur's human capital. Here lower case letters k_e, l_e, h are used to emphasize that equation (1.2.3) is the production function of *one* non-farm enterprise. The role of entrepreneurial skill in operating businesses has been widely explored in the literature. Lucas (1978) and Jovanovic (1982) found that more talented entrepreneurs have a higher level of production and marginal product of capital at all levels of capital.

The urban industrial sector uses capital and effective labor as inputs:

$$F^u(K_u, H_u) = A_u K_u^{\gamma} H_u^{1-\gamma}, \qquad \gamma \in (0, 1), \tag{1.2.4}$$

where A_u is the urban industrial sector's total factor productivity, K_u and H_u are aggregate input of capital and efficient labor input respectively.

1.2.1 Solving Households Problem

Individuals only consume in the second period. Since we have not introduced the labor market, let us use $W(h)$ to denote the life-time income of a rural migrant with human capital h. Given exogenous prices for agricultural goods, c_f, non- agricultural goods c_e, and urban manufacturing goods c_u, a private agent chooses the optimal consumption allocation to maximizes his lifetime utility:

$$\begin{aligned} \max_{\{c_f, c_e, c_m\}} \quad U &= lnc_f + lnc_e + lnc_u \\ s.t. \quad c_f + p_e c_e + p_u c_u &\leq W(h) \\ \text{given } &\{p_e, p_u, r\} \end{aligned} \tag{1.2.5}$$

where the price of agricultural goods c_f is assumed to be unity as a normalization. p_e and p_u are the relative prices of non-farm goods and urban manufacturing goods to agricultural goods. These two relative prices are assumed to be exogenously given. If an economy's commodity market is open and the trade with the world commodity market is free, then its goods' prices will not be affected by its production level in that it can always import/export at the world price. r is the real net interest rate measured in units of agricultural goods, which equals to the world interest rate given that the economy's urban sector has free access to the international capital markets. Following Gine and Townsend (2002), it is assumed that the credit markets in China's rural area have an asymmetric feature, which allows private agents to save at rate r, but prevents them from borrowing. There are two main reasons for assuming borrowing constraints in China's rural area: first, rural residents do not have ownership over the land, hence they cannot use land as collateral against borrowing (Rozelle and Swinnen (2004), Yao (2004), Li Rozelle and Huang (2000)). Secondly, it is difficult for individuals to access credits, as the available credits in the rural area are mostly earmarked (Cheng and Xu (2003)). A later section shows that even though rural-origin individuals cannot borrow, the asymmetric capital market allows deposits at a rate r, which gives rise to the opportunity cost of capital. A rural agent solves the utility maximization problem as described in equation (1.2.5), which gives the optimal choices for the three types of goods:

$$\begin{aligned} c_f^* &= W(h)/3 \\ c_e^* &= W(h)/(3p_e) \\ c_u^* &= W(h)/(3p_u) \end{aligned} \tag{1.2.6}$$

The optimal choices for consumption goods yields the maximized utility, which is a linear function of the logarithm of life-time income W(h):

$$\begin{aligned} &V(h) = 3lnW(h) - B \\ &\quad\text{where,} \\ &\quad B \equiv ln(3p_f) + ln(3p_e) + ln(3p_u) \end{aligned} \tag{1.2.7}$$

Therefore, the household utility maximization problem is transformed into a life-time income maximization problem. The life-time income level $W(h)$ is determined by migration and occupational choices, which will be elaborated more later.

1.2.2 Solving The Urban Manufacturing Sector's Problem

The urban manufacturing sector is modeled as an aggregate production, in which the firm chooses the optimal aggregate levels of efficient labor H_u and capital K_u to maximize profit:

$$\begin{aligned} &\max_{\{K_u, H_u\}} \quad A_u K_u^{\gamma} H_u^{1-\gamma} - (1+r)K_u - w_u H_u \\ &\quad\text{given} \quad \{1+r, w_u\} \end{aligned} \tag{1.2.8}$$

I assume that the urban sector has free and unlimited access to international capital markets, thus they can always borrow and lend at a constant interest rate r. This is a reasonable assumption for developing countries like China, since the fluctuation in its capital demand does not have a significant impact on the world interest rate. The first order conditions for the profit maximization problem are:

$$\begin{aligned} A\gamma K_u^{\gamma-1} H_u^{1-\gamma} &= 1 + r \\ A(1-\gamma) K_u^{\gamma} H_u^{-\gamma} &= w_u \end{aligned} \tag{1.2.9}$$

The ratio of capital input to efficient labor input can be written in two expressions:

$$\frac{K_u}{H_u} = \frac{\gamma}{1-\gamma}\frac{w_u}{1+r}$$
$$\frac{K_u}{H_u} = (\frac{A_u\gamma}{1+r})^{\frac{1}{1-\gamma}} \tag{1.2.10}$$

$$\text{Thus,} \quad \frac{\gamma}{1-\gamma}\frac{w_u}{1+r} = (\frac{A_u\gamma}{1+r})^{\frac{1}{1-\gamma}} \tag{1.2.11}$$

Because the interest rate is constant, we can see from equation (1.2.11) that the urban efficiency wage rate only depends on the urban production technology, therefore,

$$w_u \propto A_u^{\frac{1}{1-\gamma}} \tag{1.2.12}$$

In this paper, we focus on one small rural area while taking the urban wage as exogenous, and study how the growing urban wage affects the rural migration and the rural wage.

1.2.3 Solving Rural Farm Production's Problem

The rural land is owned by the state. It is assumed that land market does not exist, since land is not permitted to be purchased or sold in China by law. The farm production uses labor and land as inputs. The profit maximization problem for the farm sector is:

$$\max_{\{L_f\}} \quad A_f L_f^{1-\eta} Z_f^{\eta} - w_r L_f$$
$$\text{given} \quad \{w_r, Z_f\} \tag{1.2.13}$$

where w_r is the wage rate prevailing in the rural area. Therefore labor demand from the agricultural sector is given by:

$$L_f = \Big[\frac{(1-\eta)A_f}{w_r}\Big]^{\frac{1}{\eta}} Z_f \tag{1.2.14}$$

1.2.4 Solving Rural Non-farm Production's Problem

Facing borrowing constraints, potential entrepreneurs in the rural area completely rely on self-own fund to start businesses. Hence, the capital input in non-farm businesses cannot exceed the owners' saving.

An entrepreneur chooses the optimal capital and labor inputs for his rural non-farm business, given his own human capital h, the wage to hire labor in rural area w_r, the opportunity cost of using his own saving $(1+r)$, and the capital constraint. Because of the restrictions imposed on rural-urban migration in China, migrants face costs for transportation, housing, fees for urban working permits. Self-owned capital of a migrant is $(1-\tau)w_u h$, where τ captures all kinds of cost for a migrant to work in cities. The profit maximization problem of an entrepreneur is:

$$\begin{aligned} \max_{\{k_{e,t+1}, l_{e,t+1}, h\}} \quad & F(k_{e,t+1}, l_{e,t+1}) - (1+r)k_{e,t+1} - w_{r,t+1}l_{e,t+1} \\ s.t. \quad & k_{e,t+1} \leq (1-\tau)w_{u,t}h \end{aligned} \tag{1.2.15}$$

If the constraint is not binding, i.e. the optimal capital input $k_{e,t+1}$ does not exceed the migrant's own saving $(1-\tau)w_{u,t}h$, then the profit maximization problem has an interior solution. Otherwise, corner solution prevails. The first order conditions for an interior solution are given by:

$$\begin{aligned} \alpha A_e h k_{e,t+1}^{\alpha-1} l_{e,t+1}^{\beta} &= 1+r \\ \beta A_e h k_{e,t+1}^{\alpha} l_{e,t+1}^{\beta-1} &= w_{r,t+1} \end{aligned} \tag{1.2.16}$$

From the equation (1.2.16) we can find the capital-labor ratio given the interest rate and rural wage:

$$\frac{k_{e,t+1}^U}{l_{e,t+1}^U} = \frac{w_{r,t+1}}{1+r}\frac{\alpha}{\beta} \tag{1.2.17}$$

The unconstrained capital input $k_{e,t+1}^U$ and labor input $l_{e,t+1}^U$, are obtained as:

$$\begin{aligned} k_{e,t+1}^U &= \underbrace{\left[\frac{\alpha^{1-\beta}\beta^{\beta}}{(1+r)^{1-\beta}}\frac{A_{e,t+1}}{w_{r,t+1}^{\beta}}\right]^{\frac{1}{1-\alpha-\beta}}}_{C_1} h^{\frac{1}{1-(\alpha+\beta)}} \\ l_{e,t+1}^U &= \left[\frac{A_{e,t+1}h\beta(k_{e,t+1}^U)^{\alpha}}{w_{r,t+1}}\right]^{\frac{1}{1-\beta}} \\ &= \underbrace{\left[\frac{\alpha^{\alpha}\beta^{1-\alpha}}{(1+r)^{\alpha}}\right]^{\frac{1}{1-(\alpha+\beta)}}\left[\frac{A_{e,t+1}}{w_{r,t+1}^{1-\alpha}}\right]^{\frac{1}{1-(\alpha+\beta)}}}_{C_4} h^{\frac{1}{1-(\alpha+\beta)}} \end{aligned} \tag{1.2.18}$$

Following the solution for the unconstrained capital and labor inputs as shown in equation (1.2.18), the maximized profit for an unconstrained entrepreneur is given by:

$$\begin{aligned}\pi^U_{e,t+1} &= F(k^U_{e,t+1}, l^U_{e,t+1}, h) - (1+r)k^U_{e,t+1} - w_{e,t+1}l^U_{e,t+1} \\ &= \underbrace{(1-\alpha-\beta)\Big[\frac{\alpha^\alpha\beta^\beta}{(1+r)^\alpha}\Big]^{\frac{1}{1-\alpha-\beta}}\Big[\frac{A_{e,t+1}}{w^\beta_{r,t+1}}\Big]^{\frac{1}{1-\alpha-\beta}}}_{C_2} h^{\frac{1}{1-\alpha-\beta}}\end{aligned} \tag{1.2.19}$$

Thus, the present value of an unconstrained entrepreneur's lifetime income is given by:

$$\begin{aligned}W_{\text{uncons}} &= (1-\tau)w_{u,t}h + \frac{\pi^U_{e,t+1}}{1+r} \\ &= (1-\tau)w_{u,t}h + (\frac{C_2}{1+r})h^{\frac{1}{1-(\alpha+\beta)}}\end{aligned} \tag{1.2.20}$$

A return migrant is an *unconstrained* entrepreneur if the capital constraint is not binding, and the maximized profit is larger than his foregone urban income. These two conditions are equivalent to the following two inequalities:

$$\begin{aligned}k^U_{e,t+1} &\leq (1-\tau)w_{u,t}h \\ \pi^U_{e,t+1} &\geq (1-\tau)w_{u,t+1}h\end{aligned} \tag{1.2.21}$$

or, in a more concise form:

$$\begin{aligned}\frac{(1-\tau)w_{u,t}}{C_1} \geq h^{\sigma_1} &\geq \frac{(1-\tau)w_{u,t+1}}{C_2} \\ \text{where} \quad 1+\sigma_1 &\equiv \frac{1}{1-(\alpha+\beta)}\end{aligned} \tag{1.2.22}$$

On the other hand, if saving from migration is less than the unconstrained optimal capital input, then this entrepreneur is constrained by the borrowing constraints. Had he been able to borrow, he would have raised more capital and established a larger firm. A constrained entrepreneur uses all of his saving, $(1-\tau)w_{u,t}h$, as capital inputs for the non-farm business and chooses labor input accordingly. The constrained capital and labor inputs are given by:

$$\begin{aligned}k^C_{e,t+1} &= (1-\tau)w_{u,t}h \\ l^C_{e,t+1} &= \Big[\frac{A_{e,t+1}h\beta(k^C_{e,t+1})^\alpha}{w_{r,t+1}}\Big]^{\frac{1}{1-\beta}} \\ &= \underbrace{\Big[\frac{A_{e,t+1}\beta(1-\tau)^\alpha w^\alpha_{u,t}}{w_{r,t+1}}\Big]^{\frac{1}{1-\beta}}}_{C_5} h^{\frac{1+\alpha}{1-\beta}}\end{aligned} \tag{1.2.23}$$

Following the solution for constrained capital and labor inputs, the maximized profit for a constrained entrepreneur is given by:

$$\begin{aligned}\pi^C_{e,t+1} &= F(k^C_{e,t+1}, l^C_{e,t+1}, h) - (1+r)k^C_{e,t+1} - w_{e,t+1}l^C_{e,t+1} \\ &= (1-\beta)\beta^{\frac{\beta}{1-\beta}}\left[\frac{A_{e,t+1}(1-\tau)^\alpha w^\alpha_{u,t}}{w^\beta_{r,t+1}}\right]^{\frac{1}{1-\beta}} h^{\frac{1+\alpha}{1-\beta}} - (1+r)(1-\tau)w_{u,t}h\end{aligned} \tag{1.2.24}$$

Hence the present value of a constrained entrepreneur's lifetime income is given by:

$$\begin{aligned}W_{\text{cons}} &= w_{u,t}h + \frac{\pi^C_{e,t+1}}{1+r} \\ &= \underbrace{\frac{(1-\beta)\beta^{\frac{\beta}{1-\beta}}}{1+r}\left[\frac{A_{e,t+1}(1-\tau)^\alpha w^\alpha_{u,t}}{w^\beta_{r,t+1}}\right]^{\frac{1}{1-\beta}}}_{C_3} h^{\frac{1+\alpha}{1-\beta}}\end{aligned} \tag{1.2.25}$$

A return migrant is a *constrained* entrepreneur if the capital constraint is binding, and the maximized profit is larger than his foregone urban income. These two conditions are equivalent with the following two inequalities:

$$\begin{aligned}k^U_{e,t+1} &> (1-\tau)w_{u,t}h \\ \pi^C_{e,t+1} &\geq (1-\tau)w_{u,t+1}h\end{aligned} \tag{1.2.26}$$

Or, in a more compact form:

$$\begin{aligned}h^{\sigma_1} &> \frac{(1-\tau)w_{u,t}}{C_1} \\ h^{\sigma_2} &> \frac{(1-\tau)[w_{u,t} + \frac{w_{u,t+1}}{1+r}]}{C_3} \\ \text{where} \quad 1+\sigma_2 &\equiv \frac{1+\alpha}{1-\beta}\end{aligned} \tag{1.2.27}$$

1.2.5 Occupational Choices of Households

So far I have solved the problems for the rural farm sector, the urban manufacturing sector and the rural non-farm production sector operated by return entrepreneurs. There is now sufficient information to set up the income profile for each occupation category. The goal of this section is to determine rural individuals' occupational choices and the corresponding income levels. In this model, rural residents are heterogeneous in the initial human capital, therefore the occupational decisions hinge on the human capital level. Before stating the mathematical expressions, let me briefly explain the intuition. We can think of rural individuals' human capital as drawn from some distribution (such as log-normal distribution). After a rural agent is born, the human capital level is realized and known. If this human capital level is sufficiently low, the best choice is to work in agriculture sector, which does not require any human capital input. Otherwise, the rural agent can migrate and work in urban sector, which rewards higher human capital. Therefore, the first human capital threshold is determined between non-migrants and migrants. As modeled in the rural entrepreneurship section, the human capital of an entrepreneur is so essential to the profitability of his business that human capital has increasing returns to scale in entrepreneurship. As a comparison, a return entrepreneur's income profile is convex in his human capital while a permanent migrant's income is only linear in human capital. Therefore a second threshold between permanent migrants and return entrepreneurs is generated. Lastly, for all entrepreneurs, the available capital comes solely from their savings during migration (which is linear in human capital), which might be lower or higher than the desired capital input (as the capital input in the entrepreneurship is convex in entrepreneur's human capital). Thus, a third human capital threshold is determined between unconstrained and constrained return entrepreneurs.

In the following table, the present values of lifetime income $W(h)$ are listed for non-migrants, permanent migrants, and temporary migrants (including unconstrained and constrained entrepreneurs)

Income and occupational choices

W(h)	Young	Old
$w_{r,t} + \frac{w_{r,t+1}}{1+r}$	Stay in rural	Stay in rural
$(1-\tau)[w_{u,t}h + \frac{w_{u,t+1}h}{1+r}]$	Migrate to cities	Stay in cites
$(1-\tau)w_{u,t}h + \frac{\pi^U_{e,t+1}}{1+r}$	Migrate to cities	Return to rural
$(1-\tau)w_{u,t}h + \frac{\pi^C_{e,t+1}}{1+r}$	Migrate to cities	Return to rural

If we compare the occupational choices pair-wise, two possible sets of the human capital thresholds emerge. The first scenario happens when non-migrants, permanent migrants, unconstrained and constrained entrepreneurs all exist in the economy, which has three human capital thresholds. The second scenario is possible when all the entrepreneurs are constrained, which has only two human capital thresholds.

Possibility 1: Both constrained and unconstrained entrepreneurs exist

Human capital	Young	Old	Designation
$0 \leq h < \hbar_{1,t}$	Stay in rural	Stay in rural	Non-migrants
$\hbar_{1,t} \leq h < \hbar_{2,t}$	Migrate to cities	Stay in cites	Permanent migrants
$\hbar_{2,t} \leq h < \hbar_{3,t}$	Migrate to cities	Return to rural	Unconstr. entrep.
$\hbar_{3,t} \leq h < \infty$	Migrate to cities	Return to rural	Constr. entrep.

Possibility 2: All the entrepreneurs are constrained.
entrepreneurs

Human capital	Young	Old	Designation
$0 \leq h < \hbar_{1,t}$	Stay in rural	Stay in rural	Non-migrants
$\hbar_{1,t} \leq h < \hbar_{4,t}$	Migrate to cities	Stay in cites	Permanent migrants
$\hbar_{4,t} \leq h < \infty$	Migrate to cities	Return to rural	Constr. entrep.

where, the human capital thresholds are as shown below:

$$\hbar_{1,t} = \frac{w_{r,t}(1+r) + w_{r,t+1}}{(1-\tau)[w_{u,t}(1+r) + w_{u,t+1}]} \tag{1.2.28}$$

$$\hbar_{2,t} = (\frac{(1-\tau)w_{u,t+1}}{C_2})^{\frac{1}{\sigma_1}} \tag{1.2.29}$$

$$\hbar_{3,t} = (\frac{(1-\tau)w_{u,t}}{C_1})^{\frac{1}{\sigma_1}} \tag{1.2.30}$$

$$\hbar_{4,t} = (\frac{(1-\tau)[w_{u,t} + \frac{w_{u,t+1}}{1+r}]}{C_3})^{\frac{1}{\sigma_2}} \tag{1.2.31}$$

Even though there are two possibilities in theory, it turns out that the second possibility never occurs in simulation, in other words, both constrained and unconstrained entrepreneurs always exist at the same time.

1.3 Definition of Equilibrium

DEFINITION 1. A competitive equilibrium for this economy is a set of human capital thresholds $\{\hbar_{1t}, \hbar_{2t}, \hbar_{3t}, \hbar_{4t}\}_{t=1}^{\infty}$, which determine the occupational choices for rural agents; a sequence of rural wages $\{w_{r,t}\}_{t=1}^{\infty}$; a sequence of rural population $\{N_t\}_{t=1}^{\infty}$; and a sequence of migration rates ψ_t, satisfying

1. (Households' problem) Given the prices $\{w_{r,t}, w_{u,t}, 1+r\}_{t=1}^{\infty}$, the occupational choices solve the rural households' utility maximization problem;

2. (Rural farm production's problem) Given the prices $\{w_{r,t}, w_{u,t}, 1+r\}_{t=1}^{\infty}$, the rural farm's profit maximization problem is solved;

3. (Rural non-farm production's problem) Given the prices $\{w_{r,t}, w_{u,t}, 1+r\}_{t=1}^{\infty}$, the rural non-farm businesses' profit maximization problem is solved;

4. The rural labor market clears:

$$\underbrace{\left[\frac{(1-\eta)A_{ft}}{w_{rt}}\right]^{\frac{1}{\eta}} Z_t}_{\text{Labor demand from farm sector}} \quad \underbrace{+ N_{t-1}\int_{\hbar_{2t-1}}^{\hbar_{3t-1}} l_e^U(h)d\Phi(h) + N_{t-1}\int_{\hbar_{3t-1}}^{\infty} l_e^C(h)d\Phi(h)}_{\text{Labor demand from non-farm sector}}$$

$$= \quad \underbrace{N_{t-1}\int_0^{\hbar_{1t-1}} d\Phi(h)}_{\text{Labor supply of old non-migrants}} \quad + \quad \underbrace{N_t\int_0^{\hbar_{1t}} d\Phi(h)}_{\text{Labor supply of young non-migrants}} \tag{1.3.1}$$

5. The rural population evolves according to

$$N_t = N_{t-1}\psi_t \tag{1.3.2}$$

$$\text{where,} \qquad \psi_t = 1 - \int_{\hbar_{1t-1}}^{\hbar_{2t-1}} d\Phi(h)$$

where ψ_t is the rate at which the rural population decreases.

DEFINITION 2. A balanced growth path for this economy is a competitive equilibrium, which, in addition to conditions 1-5 from the previous definition satisfies:

6. $w_{r,t+1} = \rho w_{r,t}, \quad \text{for all} \quad t = 0, 1, 2, ...$,
7. $N_{r,t+1} = \psi N_{r,t}, \quad \text{for all} \quad t = 0, 1, 2, ...$
8. $\hbar_{1,t} = \hbar_1, \quad \text{for all} \quad t = 0, 1, 2, ...$
9. $\hbar_{2,t} = \hbar_2, \quad \text{for all} \quad t = 0, 1, 2, ...$
10. $\hbar_{3,t} = \hbar_3, \quad \text{for all} \quad t = 0, 1, 2, ...$

where ρ and ψ are some constants.

Definition 2 says that in a stationary competitive equilibrium, the rural wage is growing at a constant rate ρ over time, while the rural population is declining at a constant rate ψ over time. The crucial determinants for the occupational choices in this model are the human capital thresholds. In the balanced growth path, the $\hbar's$ are all constants.

1.4 Existence of Balanced Growth Path

Proposition 1. Assume the TFPs in the three production sectors are exogenous, growing at different but constant rates: the rural farm TFP grows at rate λ; the rural non-farm production TFP grows at rate μ; the urban production TFP grows at rate ζ. The per capita land holding increases at rate θ. If (i) the urban and rural wages are growing at the same rate, ρ ; (ii) equation (1.4.1)-(1.4.2) are satisfied, then the balanced growth path exists.

$$\mu = \zeta^{\frac{1-\alpha}{1-\gamma}} \tag{1.4.1}$$

$$\theta = [\frac{\zeta^{\frac{1}{1-\gamma}}}{\lambda}]^{\frac{1}{\eta}} \tag{1.4.2}$$

Proof of Proposition 1: I will show that if rural and urban wages are growing at the same rate ρ, and equation (1.4.1)-(1.4.2) are satisfied, then all the thresholds are constant over time.

The first human capital threshold is between non-migrants and permanent migrants:

$$\begin{aligned} \hbar_{1,t} &= \frac{w_{r,t}(1+r) + w_{r,t+1}}{(1-\tau)[w_{u,t}(1+r) + w_{u,t+1}]} \\ &= \frac{(w_{r0}(1+r) + w_{r0}\rho)\rho^t}{(w_{u0}(1+r) + w_{u0}\rho)\rho^t} \frac{1}{1-\tau} \\ &= \frac{w_{r0}(1+r) + w_{r0}\rho}{w_{u0}(1+r) + w_{u0}\rho} \frac{1}{1-\tau} \end{aligned} \tag{1.4.3}$$

Therefore, $\hbar_1$ is independent with time, if rural wage grows at the same rate as urban wage.

The second human capital threshold is between permanent migrants and unconstrained entrepreneurs:

$$
\begin{aligned}
\hbar_{2,t} &= \Big[\frac{(1-\tau)w_{u,t+1}}{C_2}\Big]^{\frac{1}{\sigma_1}} \\
&= \Big[\frac{(1-\tau)w_{u,t+1}}{(1-\alpha-\beta)\Big[\frac{\alpha^\alpha\beta^\beta}{(1+r)^\alpha}\Big]^{\frac{1}{1-\alpha-\beta}}\Big[\frac{A_{e,t+1}}{w_{r,t+1}^\beta}\Big]^{\frac{1}{1-\alpha-\beta}}}\Big]^{\frac{1}{\sigma_1}} \\
&= \Gamma_1\Big[\frac{(1-\tau)w_{u,0}\rho^{t+1}}{\frac{(A_{e,0})^{\frac{1}{1-\alpha-\beta}}\mu^{\frac{1}{1-\alpha-\beta}(t+1)}}{(w_{r,0})^{\frac{\beta}{1-\alpha-\beta}}\rho^{\frac{\beta}{1-\alpha-\beta}(t+1)}}}\Big]^{\frac{1}{\sigma_1}} \qquad (1.4.4)\\
&= \Gamma_1\Big[\frac{(1-\tau)w_{u,0}w_{r,0}^{\frac{\beta}{1-\alpha-\beta}}}{A_{e,0}^{\frac{1}{1-\alpha-\beta}}}\Big]^{\frac{1}{\sigma_1}} \qquad \text{because} \quad \mu=\rho^{1-\alpha}
\end{aligned}
$$

where,

$$\Gamma_1 = (1-\alpha-\beta)^{1-\frac{1}{\alpha+\beta}}\Big[\frac{\alpha^\alpha\beta^\beta}{(1+r)^\alpha}\Big]^{-\frac{1}{\alpha+\beta}} \qquad (1.4.5)$$

Therefore, $\hbar_2$ is constant over time.

The third threshold is between unconstrained entrepreneurs and constrained entrepreneurs:

$$
\begin{aligned}
\hbar_{3,t} &= \Big[\frac{(1-\tau)w_{ut}}{C_1}\Big]^{\frac{1}{\sigma_1}} \\
&= \Big[\frac{(1-\tau)w_{ut}}{\Big[\frac{\alpha^{1-\beta}\beta^\beta}{(1+r)^{1-\beta}}\frac{A_{e,t+1}}{w_{r,t+1}^\beta}\Big]^{\frac{1}{1-\alpha-\beta}}}\Big]^{\frac{1}{\sigma_1}} \\
&= \Gamma_2\Big[\frac{(1-\tau)w_{u,0}\rho^{t}}{\frac{(A_{e,0}\mu)^{\frac{1}{1-\alpha-\beta}}\mu^{\frac{1}{1-\alpha-\beta}t}}{(w_{r,0}\rho)^{\frac{\beta}{1-\alpha-\beta}}\rho^{\frac{\beta}{1-\alpha-\beta}t}}}\Big]^{\frac{1}{\sigma_1}} \qquad (1.4.6)\\
&= \Gamma_2\Big[\frac{(1-\tau)w_{u,0}w_{r,0}^{\frac{\beta}{1-\alpha-\beta}}}{A_{e,0}^{\frac{1}{1-\alpha-\beta}}\rho}\Big]^{\frac{1}{\sigma_1}} \qquad \text{because} \quad \mu=\rho^{1-\alpha}
\end{aligned}
$$

where,

$$\Gamma_2 = \Big[\frac{\alpha^{1-\beta}\beta^\beta}{(1+r)^{1-\beta}}\Big]^{-\frac{1}{\sigma_1}} \qquad (1.4.7)$$

Therefore, $\hbar_3$ is invariant over time.

The fourth threshold shows up only when there are no unconstrained entrepreneurs, and it divides the choices between permanent migrants and constrained entrepreneurs:

$$
\begin{aligned}
\hbar_{4,t} &= \Big[\frac{(1-\tau)(w_{u,t}(1+r)+w_{u,t+1})}{C_3}\Big]^{\frac{1}{\sigma_2}} \\
&= \Big[\frac{(1-\tau)(w_{u,t}(1+r)+w_{u,t+1})}{(1-\beta)\beta^{\frac{\beta}{1-\beta}}\left[\frac{A_{e,t+1}(1-\tau)^{\alpha}w_{u,t}^{\alpha}}{w_{r,t+1}^{\beta}}\right]^{\frac{1}{1-\beta}}}\Big]^{\frac{1}{\sigma_2}} \\
&= \Big[\frac{(1-\tau)w_{u,0}(1+r+\rho)\rho^{t}}{(1-\beta)\beta^{\frac{\beta}{1-\beta}}\left[\frac{A_{e,0}\mu(1-\tau)^{\alpha}}{w_{r,0}^{\beta}\rho^{\beta}}\right]^{\frac{1}{1-\beta}}\rho^{t}}\Big]^{\frac{1}{\sigma_2}} \\
&= \Big[\frac{(1-\tau)w_{u,0}(1+r+\rho)}{(1-\beta)\beta^{\frac{\beta}{1-\beta}}\left[\frac{A_{e,0}\mu(1-\tau)^{\alpha}}{w_{r,0}^{\beta}\rho^{\beta}}\right]^{\frac{1}{1-\beta}}}\Big]^{\frac{1}{\sigma_2}}
\end{aligned}
\tag{1.4.8}
$$

Therefore, all the thresholds in human capital are constant over time.

In the following, I will show that if human capital thresholds are constant, then the rural and urban wages have to grow at the same rate. Let us assume that rural wage is growing at rate ρ_1, and urban wage is growing at rate ρ_2. As shown before, the first human capital threshold is expressed as:

$$
\begin{aligned}
\hbar_{1,t} &= \frac{w_{r,t}(1+r)+w_{r,t+1}}{(1-\tau)[w_{u,t}(1+r)+w_{u,t+1}]} \\
&= \frac{(w_{r0}(1+r)+w_{r0}\rho_1)\rho_1^t}{(w_{u0}(1+r)+w_{u0}\rho_2)\rho_2^t}\frac{1}{1-\tau} \\
&= \underbrace{\Big[\frac{w_{r0}(1+r)+w_{r0}\rho_1}{w_{u0}(1+r)+w_{u0}\rho_2}\frac{1}{1-\tau}\Big]}_{\text{Constant}}(\rho_1/\rho_2)^t
\end{aligned}
\tag{1.4.9}
$$

Therefore, $\hbar_{1,t}$ cannot be constant over time unless $\rho_1 = \rho_2$. In other words, if human capital thresholds are constant, then the rural and urban wages must grow at the same rate. ■

Properties of Balanced Growth Path: On the balanced growth path, the rate at which the rural population decreases is constant over time, because the human capital thresholds are constant over time:

$$\psi = 1 - \int_{\hbar_1}^{\hbar_2} d\Phi(h) \tag{1.4.10}$$

On the balanced growth path, the rural labor market clearing condition (1.3.1) is described by the following expression:

$$\begin{aligned}&\left[\frac{(1-\eta)A_{f0}}{w_{r0}}\right]^{\frac{1}{\eta}}\xi_0\psi + \int_{\hbar_2}^{\hbar_3} l_e^U(h)d\Phi(h) + \int_{\hbar_3}^{\infty} l_e^C(h)d\Phi(h)\\ &= \int_0^{\hbar_1} d\Phi(h) + \psi\int_0^{\hbar_1} d\Phi(h)\end{aligned} \tag{1.4.11}$$

where,

$$l_e^U = \left[\frac{\alpha^\alpha\beta^{1-\alpha}}{(1+r)^\alpha}\right]^{\frac{1}{1-(\alpha+\beta)}}\left[\frac{A_{e,0}}{w_{r0}^{1-\alpha}}\right]^{\frac{1}{1-\alpha-\beta}} h^{\frac{1}{1-(\alpha+\beta)}} \tag{1.4.12}$$

$$l_e^C = \left[\frac{A_{e,0}\mu\beta(1-\tau)^\alpha w_{u0}^\alpha}{w_{r0}\rho}\right]^{\frac{1}{1-\beta}} h^{\frac{1+\alpha}{1-\beta}} \tag{1.4.13}$$

There are several points that we need to bear in mind: first, even though the rural and urban wages are growing at the same rate, due to the differences in the initial period, the income inequalities between any two occupations will not diminish, so that migration will continue. Secondly, the rural area is deprived of capital needed for businesses, therefore rural agents are severely restrained in exploring business opportunities; however, the rural-urban migration creates a channel allowing capital to flow from cities to the rural area thanks to the return migrants. If labor mobility were prohibited, rural individuals would have no chance of becoming entrepreneurs. For the rural area, the out-migration reduces local employment and return migrants help create new jobs at the mean time. Lastly, the rural area also needs technological innovations so that the farm production and non-farm production can both undergo steady technological growth.

1.5 Model Simulations

In this section, the model is solved numerically. A list of parameter values is presented in table (5). On December 1978, the 3rd Session of the 11th Communist Party of China (CPC) Meeting was held in Beijing. During this historically important meeting, China's main leaders initiated the rural Household Responsibility System reform. Therefore, 1978 can be taken as our initial period. Brandt et al.(2008) documented and calculated the TFP levels based on real Chinese data. They stated that in 1978, the TFP in non-agricultural non-state sector was 1.5 times that of agricultural sector, and TFP in non-agricultural state sector was 1.6 times that of agricultural sector. In this paper, the rural non-farm businesses are owned by private agents, hence they can be categorized into the non-agricultural non-state sector. The urban sector in this paper is not differentiated between state owned or non-state owned, so it is reasonable to pick the TFP in urban sector to be 1.6 times that of the rural farm sector. In this paper, the Total Factor Productivity (TFP) for three sectors in the initial period are chosen to be 2, 3, and 3.2 respectively for the rural farm sector, the rural non-farm sector and the urban sector.

Secondly, we need to set the growth rate of the TFP in the agricultural sector in China. Brandt et al. (2008) showed that the TFP in the agricultural sector in China increased at annual rates of 5.38% from 1978 to 2002. Rozelle and Swinnen (2004) showed that the annual growth rates for TFP in agricultural sector in China from 1979 to 1994 ranged from 3.8% to 6.1% depending on the types of crops (rice, wheat, maize, soybean, etc). Fan and Zhang (2002) illustrated that while the TFP growth rate in agriculture was 5.34% using constant price, it was actually 3.28% when using their own adjustment calculation. In this paper, I picked λ, the growth rate of TFP in the rural farm sector to be 2.65, which is equivalent to an annual growth rate of 5%, if a model period corresponds to 20 years.

Thirdly, we need to think about the growth rate of TFP in rural non-farm sector, μ, and urban sector, ζ. Based on the construction of the urban production sector, ζ is related to the growth rate of urban wage rate ρ as shown in equation (1.2.12), so that the growth rate of urban wage is the growth rate of urban TFP to the power of $\frac{1}{1-\gamma}$. On the balanced growth path, μ is related to the growth rate of urban wage rate ρ as shown in equation (1.4.1). Thus, we need to pick five parameters μ, ζ, ρ, α and γ. Based on data from China Statistic Yearbook, the real per capita income of urban residents was 127 yuan in 1980 and 360.6 yuan in 1999, thus, ρ is set at 2.84, which is equivalent to an annual growth rate of 5.35%. The capital share in rural non-farm industry is α. Keep in mind that, the rural non-farm sector uses capital, hired labor and entrepreneurs' own human capital as inputs. I pick α to be 0.25, β to be 0.3 so that the share of capital and labor in the two hired inputs are 45% and 55% respectively. Knowing ρ, α, and γ, on the balanced growth path, the growth rate of TFP in the rural non-farm sector is 2.18, and the growth rate of TFP in the urban sector is 2.08. Brandt (2007) has documented that the growth rate of TFP in non-agricultural sector (including state and non-state owned) from 1978 to 1999 was 2, which is equivanlent to an annual growth rate of 3.5%. Thus, the choices for TFP growth rate in this paper is consistent with Brandt (2007).

Fourthly, we need to choose the migration cost, τ. The literature contains various estimates of migration cost. Zhao (1999) documented that in a survey conducted by the Ministry of Labor in 1995 on 2873 migrant workers in four large cities, the cost of transportation and housing in 1995 for an average migrant was 498.6 yuan (59.85 US dollars). Beyond that, an average migrant paid 223.1 yuan (26.78 US dollars) in order to possess "three certificates and one card" (san zheng yi ka), which are necessary for rural migrants to stay in cities legally. Therefore, the sum of the explicit cost was at least 721.7 yuan (86.64 US dollars) for an average migrant in 1995. In a recent survey conducted by the Research Team from China Congress(Guo Wu Yuan Diao Cha Zu), documented in the Investigation Report on China's Migrants (2006), there are 29.26% of migrants have their monthly income between 300-500 yuan (37.27-62.11 US dollars), 39.26% between 500-800 yuan(62.11-99.37 US dollars) and 27.9% above 800 yuan. The survey also showed that migrants are very frugal on their in order to save as much money as possible; there are 52.47% of migrants spend less than 10% of their income on housing, 35.8% spend between 10% to 20% of income, and only 11.11% spend more than 20% of income on housing. Therefore, I choose the migration cost τ, to be 0.15 in this paper; in other words, 15% of a migrant's income is spent on transportation, housing, permission, etc.

Lastly, we need to choose appropriate parameters for the human capital distribution. Human capital h follows a log-normal distribution, i.e. $lnh \sim N(\nu, \sigma)$. In this paper, $\sigma = 0.5$ and $\nu \in [-0.2, 1.2]$ so that the human capital median ranges from 0.82 to 3.32 and its variance has the value between 0.24 and 4.02.

After we choose values for all the parameters we can do model simulations and compare the simulated results with the real data. Our goal is the match the migration pattern of China over the past two decades. Table (4) shows that from 1978 to 2002, the share of rural population has decreased from 83% to 61% of the total population. This means that the rural population has shrunk about 26.5%. We can use this data to match our simulated result on migration rate in our model. This pined down the parameter ν in the human capital distribution to be 0.3158, or equivalently, the median human capital is 1.37 for the case of China.

1.5.1 Simulation Results

We first investigate the trend of each occupation in the rural area. Figure (4) shows that, on the balanced growth path, the fractions of non-migrants, permanent migrants, unconstrained entrepreneurs and constrained entrepreneurs are 62.80%, 26.44%, 8.95% and 1.81% respectively. Because the volume of out-migration persistently exceeds that of return migration, rural population decreases over time, as shown in figure (5). The rural population in the model decreases at the rate of 26.44%, which matches China's data 26.5% (see table (4)). If we normalize the total rural population in the first period to be one, then after 20 years (one period), the total rural population falls to 0.7356, after 40 years, it drops to 0.5412, and after 100 years, the rural population is only 0.2929.

This model also predicts how the rural wage responds to the growing urban wage. We set the urban wage growth rate ρ to be 2.82, which is identical to an annual growth rate of 5.35%. On the balanced growth path, the rural wage grows at the same rate as the exogenous urban wage. Figure (6) depicts the evolution of rural and urban wages in China. It appears that the urban wage is lower than the rural wage; however, since the urban wage is paid for each human capital unit, a migrant's income equals the urban wage multiplied by human capital. Figure (7) shows the median income of each occupation over time. On the balanced growth path, there is no variation over time in ratios between median incomes in any two occupations, as proven in Claim 3. The median income of permanent migrants is about 1.4 times that of non-migrants, and the median income of constrained entrepreneurs is about 6 times that of non-migrants.

The self-selection of migrants may potentially have a big influence on the rural area. On one hand, large net outflows of better educated migrants can result in a brain drain for the countryside, on the other hand, the migrants who choose to return bring capital back to the rural area and provide more employment opportunities in their hometown. This naturally leads to a question: what are the effects of policies that promote rural education? If the overall human capital in the rural area improves, will there be more permanent migrants and entrepreneurs? To answer this question, we need to examine the impacts of human capital variation on the occupational choices. In the simulation described in figure (8), we let the median human capital in the rural area to vary while keeping the migration cost at the value for China ($\tau = 0.15$). With the median human capital increasing gradually from 0.82 to 3.32, the rural non-migrant proportion (blue) monotonically decreases from 83% to 29%; the permanent migrant proportion undergoes a non-monotonic change: it rises from 14.84% to 28.32% and then gradually falls to 19.16%; the percentages of both types of entrepreneurs (red and light blue) dramatically increase from less than 1% to 30% and 20% respectively.

The main lesson of figure (8) is that changes in human capital have distinct effects on the four occupations, due to various returns to human capital across these occupations. The rural farm sector does not compensate human capital, the urban sector pays for human capital in a linear fashion, and the rural non-farm businesses exhibit increasing returns to entrepreneurs' own human capital. Therefore, as overall human capital increases, some rural residents will first move from the non-migrant class to the permanent migrant class, and furthermore, move from permanent migrant class to the return entrepreneur class. This explains the inverted U-shaped relation between the permanent migrant proportion and the median human capital. When human capital increases from a very low level, most of the occupational switching occurs between non-migrants and permanent migrants. Due to promoted human capital, some "would be" non-migrants choose to migrate, which corresponds to the upward sloping section. If human capital rises from a relatively high level, then we will observe people mostly switch from permanent migrant class to the return entrepreneur class, so the fraction of permanent migrants drops, which corresponds to the downward sloping section.

Migration cost is also crucial in determining rural migration patterns. In another simulation, the model examines the consequences of policies that loosen or tighten the restrictions on rural-urban migration. The simulation described in figure (9) keeps the median human capital fixed, while let the migration cost to vary from 0 to 0.2. At the current migration cost in China ($\tau = 0.15$), the fractions of the four occupations are 62.80%, 26.44%, 8.95% and 1.81%. Under a policy that completely loosens the migration restrictions so that migration cost falls to zero, the proportions of the four occupations are 57.12%, 37.33%, 4.83% and 0.72%. This indicates that, more migrants - including permanent migrants and return entrepreneurs - appear when migration is less costly. On the contrary, when migration cost surges, a subset of permanent migrants who have relatively low human capital will then choose not to migrate, which leads to an enlarging non-migrants class; meanwhile, a subset of permanent migrants whose human capital is relatively high will choose only to temporarily migrate, which contributes to a bigger entrepreneurs group. Therefore, policies that change migration cost will impact the occupational composition differently depending on the human capital level of the rural area. If migration cost increases when the rural human capital level is low, then permanent migrants are more likely to switch to the non-migrants group; however, if migration cost increases when the rural human capital is high, then the permanent migrants are more likely to switch to the return entrepreneurs group.

Figure (11) presents the pattern of three human capital thresholds for occupational choices. First of all, all the three thresholds are monotonically increasing when the median human capital grows regardless of migration costs. The left upper panel in figure (11) shows the case where there is no migration cost ($\tau = 0$). When the median human capital is at its lowest value 0.82, it is below the first threshold (blue), 1.2. Therefore, more than 50% of rural residents are non-migrants. When the median human capital increase to its peak level 3.32, the person whose human capital is at the median will choose to migrate as 3.32 falls into the intervals between the first and second thresholds. This implies that better education enables more occupational choices to be feasible for rural residents. As the education system improves, the rural area changes from one that has a majority of its population working on the farm to one in which most people migrate or become entrepreneurs. Secondly, comparing the four sub-figures in figure (11), we find that when migration cost increases from 0 to 0.2, the second threshold (green) and the third threshold (red) both shift downward whereas the first threshold (blue) shifts upward. This shows that higher migration cost results in more non-migrants and return entrepreneurs but fewer permanent migrants.

How will the human capital level and migration cost affect the income inequality in the rural area? figure (12) depicts the pair-wise income ratios among four occupations. In the left upper sub-figure, when median human capital increases from 0.82 to 3.32, the income ratio of constrained entrepreneurs to non-migrants falls from 5.53 to 4.76, and that of unconstrained entrepreneurs to non-migrants decreases from 2.72 to 2.21. Due to the increased human capital, there are more entrepreneurs and fewer non-migrants, which pushes up the rural labor cost.[2] On the other hand, due to the improvement in the median human capital, entrepreneurs' human capital also rises. Therefore, an enhanced overall human capital level in the countryside has both a positive and negative impact on the entrepreneurs. The income of non-farm businesses is growing thanks to the higher human capital of entrepreneurs; however, the profitability is also hindered by the rising labor cost. This contributes to the declining income ratio between entrepreneurs and non-migrants.

1.6 Conclusion

This paper sets up a framework that is consistent with the observed features in China's urbanization process. Since the start of the economic reform in 1978, China has seen a large volume in rural-urban migration. The model developed here focuses on human capital in the attempt to understand this particular aspect of migration. Rural agents decide whether to migrate to cities when young, and whether to return to the countryside when old. The decisions for both periods result in a composite set of occupational choices: non-migrants work in the rural farm or non-farm sectors; permanent migrants work for the urban manufacturing sector; temporary migrants first work in the urban sector and then return to the rural area as non-farm entrepreneurs. Migration fulfills two objectives for different

[2]The positive relation between the median human capital and the rural wage is also shown in figure (13)

rural-origin individuals: for permanent migrants, urban sector jobs provide a source of high income; for temporary migrants, migration is an intermediate step through which capital is accumulated for the new business venture ahead.

This study offers several insights for the transition of developing countries like China: first, the human capital level in the rural area directly influences the outflow and inflow of rural-urban migration, and the occupational composition of the countryside. If there was no migration, there would be fewer non-farm entrepreneurs due to the borrowing constraints. Since the gradual loosening of labor mobility restrictions, rural agents have self-selected into more diverse occupations. Human capital affects income across sectors distinctively, which results in the inverted U-shaped relation between the permanent migrant fraction and the median human capital. This suggests that the education policies aiming to advance rural human capital may have different impacts on internal migration. If the initial human capital is low, the policies will yield a large permanent migrant class; in contrast, if the human capital is at a relatively high level, then we can expect a shrinking permanent migrant class with a growing entrepreneur class. Secondly, the return migrants invest their savings into rural non-farm businesses, thus local labor demand is enhanced and rural wage grow at the same rate with the urban wage; nevertheless, the income inequality is not eliminated and the rural-urban migration continues. Thirdly, borrowing constraints prohibit the development of the rural area in two dimensions: it forces potential entrepreneurs to migrate in order to obtain capital; and, it seriously limits the size of rural non-farm businesses owned by those with high human capital. If Chinese government can reform the financial institutes in the rural area, the rural industry should expect to see more growth. Lastly, even though the labor mobility restrictions have been gradually removed, rural residents remain to face various types of implicit and explicit costs of migration. As shown in this paper, higher migration costs are followed by a smaller permanent migrant class and entrepreneur class. The rural wage drops as a result of more non-migrants and less entrepreneurs in countryside.

CHAPTER II

HUMAN CAPITAL, MIGRATION REMITTANCES AND RURAL ENTREPRENEURSHIP IN CHINA: A DYNAMIC BIVARIATE PROBIT ANALYSIS

2.1 Introduction

As China experiences dazzling growth and plays an indispensable role in the global economy, there is an increasing interest in academia to learn more about this country from all dimensions. In studying its rural economy, two issues draw attentions from researchers and policy makers: first, the unprecedentedly large scale of rural-urban migration accompanying the ongoing urbanization process. Second, the transformation of rural economy from a uniform agricultural entity to a more diversified one, embracing the development of non-farm business and rural industry.

This paper aims to improve our understanding on the relationship between rural-urban migration and rural non-farm business in China. Some brief background information is provided as follows to help us gain more historical perspectives.

Since 1978, China has seen phenomenal economic growth. The success is built on economic reforms adopted in almost all major sectors — state-owned enterprises, private enterprises, agricultural production, banking and finance, trade and export sectors, etc. Rural sectors were among the earliest to receive radical policy experiments and have experienced tremendous changes and improvements over the past three decades.

The economic reform has several important implications for rural areas. First, the agricultural production switched from the former People's Commune (*Renmin Gongshe*), an inefficient production and distribution system where workers were assigned "work points" regardless of inputting effort, to the new Household Responsibility System, in which households have responsibility and residual claims on their own production. This reform of production and distribution remarkably boosted agricultural productivity; however, it also left the rural areas with a huge labor surplus. In order to ease the tension in rural labor markets, the Chinese government began conducting policies to promote rural-urban labor mobility.

Second, gradually modified policies on the rural-urban labor mobility initiated and accelerated the urbanization process in China after 1978. From 1958 till the dawn of the reform, the Household Registration system (the *Hukou* system) officially categorized all citizens into those holding "non-agricultural household registrations" and those holding "agricultural household registrations". Meanwhile, the State imposed rations on daily commodities, controlling food stamps (*Liangpiao*), oil stamps, cloth stamps, and others. Commodity stamps were distributed to urban residents according to locations of household registration, family sizes and other factors. Therefore, the combination of Household Registration system and commodity rations imposed an effective barrier to labor mobility, especially relocations from rural to urban areas. For these reasons, rural residents were denied access to many public services provided to urban Chinese only.

Since 1978, the State has loosened restrictions on rural-urban labor movements gradually. Starting in 1984, rural individuals working or doing business in urban areas were able to transfer their household registrations to corresponding towns and cities, under the condition that these individuals need to bring their own food rather than receiving food stamps from towns and cities (Chan and Zhang, 1999). In 1993, the food stamps were formally abandoned. In 1997, the State Counsel passed the new rules allowing rural citizens who worked, purchased housing, or had immediate relatives in towns to transfer their registration to local townships. More radical reforms in the household registration system have been discussed in the National People's Congress and the Chinese People's Political Consultative Conference in 2010.

As a result of the Household Registration System reform that made possible the relocation of excess rural labor, urbanization in China leaped from 17% in 1978 to 24.52% in 1986 and to 42.99% in 2005. The Bureau of Statistics of China (BSC, 2004, 2006) estimated that there were 130 million migrants in 2003. In 2009, a conservative estimate for the total number of rural migrants was 180 million, more than 14% of China's population.

The third implication of the economic reform is reflected in the more diversified rural production after 1978. Prior to the reform, rural production was dominated by farming, including growing crops, planting forests, fishing, and keeping animals. Rural non-farm production emerged once the economic reform ended the formerly uniform agricultural production methods and ownerships. Employment in rural non-farm sectors expanded from 9.163 million in 1980 to 165.363 million in 2002. The share of rural non-farm sectors in total rural employment rose from 2.98% in 1980 to 34.08% in 2002. The increasingly more versatile production technology and diversified products facilitated the development of rural non-agricultural sectors, and provided enormous employment opportunities for local residents.

The three implications of China's economic reform are closely related. The rising productivity in rural areas generated a large labor surplus, and thus led to the emergence of rural migrants. The rural migrants, living and working between rural home and cities, function to bridge the rural-urban gaps. The skills, knowledge, human capital and financial capital brought back by migrants to rural areas contribute to the development of local non-farm business.

The interactions and dynamics between rural-urban migration and rural non-farm business are complex. Murphy (2002) argues that China's return migrants made tremendous contribution to hometown non-farm business through investing and bringing up-to-date skills and technology from cities to rural areas. Her work shows that, out of all new projects in the surveyed counties in China with annual product values of more than one million yuan (0.12 million dollars), 63% were created by return migrants. The econometric literature explores to find correlations and causalities between migration related activities and rural non-farm business. Liang, et al. (2002) conduct an empirical study of the 1990 China Population Census data, and find that rural industrialization had no significant effect on the probability of migration. Their paper considers the effect of rural non-farm industry in 1985 on the likelihood of rural-urban migration, assuming the number of rural enterprises as exogenous. This assumption might not be valid given the finding in Murphy (2002) that rural migrants contributed to the development of rural industry. Brauw and Rozelle (2003) adopt a two-stage least squares method to estimate the effect of migrant labor force on household investment levels. The estimated coefficient of migration on investment is insignificant and hence they claim that there is no evidence of a link between migration and productive investments. However, their results are not sufficient to reject the hypothesis that migration and rural non-farm business ownership are correlated. Essentially, Brauw and Rozelle's estimation may reflect the fact that, rural households have less time and labor available to participate in rural business when they are actively engaged in migration related activities. The existing empirical literature overlooks the interactions between migration related activities and rural non-farm business ownership.

This shortcoming is addressed in Liu (2009), which establishes a theoretical model to study the joint decisions on migration and rural non-farm business ownership. Facing borrowing constraints, rural individuals are unable to start business when young. Nonetheless, migration to cities offers many of them an opportunity to accumulate enough capital to enter entrepreneurship when old. The capital brought back to the rural areas by return migrants contribute to the rural non-farm industry. Even though Liu (2009) addresses interactions between the decisions on migration and operating rural non-farm businesses theoretically, we still need to fill the gap in the empirical literature.

This paper adopts a dynamic bivariate probit model to explain the dynamics of migration remittances and rural non-farm business ownership. The model has been widely used in the econometrics literature to study various issues. Alessie, et al. (2001) analyze the ownership dynamics of stocks and mutual funds. Shigeki (2008) investigates the joint dynamics of spousal obesities. Stewart (2007) examines the interactions between unemployment status and employment in low-wage sector. Even though these papers have distinct topics and focuses, they have at least three features in common: first, researchers are interested in studying interactions between two economic variables. Second, these two variables are discrete, such as choices or status. Third, the state dependence effects and heterogeneities can be identified nicely through the adopted techniques. The purposes of this paper share the above mentioned features. The interactions between receiving migration remittances and operating rural non-farm business are our primary focus. Whether or not a household receives migration remittances and whether or not a household operates rural non-farm business are both status. Moreover, in a panel data analysis, we need to tackle the identification problem for the unobserved heterogeneity and the state dependence.

The dynamic bivariate probit model is applied to the China Rural Households Survey Data from 1995 to 1999. Several findings in this paper emerge. First, families receiving migration remittances are less likely to own rural non-farm business than those who do not receive remittances. Families owning rural non-farm business are less likely to receive migration remittances. This finding reflects the time and labor constraints households face when engaging in migration and non-farm business. Second, families receiving remittances in one period are more likely to receive it in the following period. Families owning non-farm business in one period are more likely to continue business operation in the following period. This point reflects that sector-specific skills, know-how, experience prevent people from frequent occupational change. Third, the estimation recognizes unobserved heterogeneity that affects both migration remittances and non-farm business. Such unobserved heterogeneity includes family network, ambition, etc. Fourth, education is important for the household income level and occupational choices. Households with more education are more likely to have families members migrate to cities and hence receive remittances. Higher education level also raises the probability of non-farm business ownership of rural families. Fifth, larger households are more likely to have migrant family members and remittances. On the other hand, larger families are also more likely to enter non-farm business in rural areas. Lastly, more males in a family is associated to higher probability of receiving remittances and owning non-farm business.

This remainder of this paper is organized as follows. Section two sets up the bivariate dynamic probit model with unobserved heterogeneities, and discusses the estimation strategy. Section three describes the data set. Section four interprets results from the maximum simulated likelihood estimation and the average partial effects estimation. Section five concludes.

2.2 Bivariate Dynamic Probit Model with Unobserved Heterogeneities

This section models binary outcomes for receiving migration remittances and rural non-farm business. The dependent variables are binary defined as:

$$y_{1,it} = \begin{cases} 1 & \text{if household receives income from family members} \\ & \text{engaging in migration activities} \\ \\ 0 & \text{if household does not receive any income related} \\ & \text{with migration} \end{cases}$$

$$y_{2,it} = \begin{cases} 1 & \text{if income from non-farm sector is larger than income from farm sector} \\ \\ 0 & \text{if income from non-farm sector is less than income from farm sector} \end{cases}$$

We can also express $y_{1,it}$ and $y_{2,it}$ in a more compact manner:

$$y_{1,it} = 1\{\text{remittances from household migrants} > 0\}$$
$$y_{2,it} = 1\{\text{income}_{\text{non-farm}} - \text{income}_{\text{farm}} > 0\},$$

The explanatory variables include $y_{1,i(t-1)}, y_{2,i(t-1)}$, which are lagged state variables, and $\mathbf{x}_{it}$, which is a vector of independent variables, assumed to be exogenous. Family characteristics such as education level, male fraction, number of labor, etc, are included in $\mathbf{x}_{it}$. We also consider unobserved heterogeneity among households, which are random variables $c_{1,i}$ and $c_{2,i}$. Finally, $u_{1,it}$ and $u_{2,it}$ are the pure random error terms. We will elaborate more on the distribution of individual heterogeneity and random error terms later. Let $y^*_{1,it}$ and $y^*_{2,it}$ to be the underlying utility, then the dynamic binary outcome model can be specified as follows:

$$\begin{aligned} \text{[migration]} \qquad & y^*_{1,it} = y_{1,i(t-1)}\gamma_{11} + y_{2,i(t-1)}\gamma_{12} + \mathbf{x}'_{it}\beta_1 + c_{1,i} + u_{1,it} \\ & y_{1,it} = 1[y^*_{1,it} > 0] \end{aligned} \tag{2.2.1}$$

$$
\begin{aligned}
\text{[Non-farm]} \qquad & y^*_{2,it} = y_{1,i(t-1)}\gamma_{21} + y_{2,i(t-1)}\gamma_{22} + \mathbf{x}'_{it}\beta_2 + c_{2,i} + u_{2,it} \\
& y_{2,it} = 1[y^*_{2,it} > 0]
\end{aligned} \tag{2.2.2}
$$

If we assume the errors (both unobserved heterogeneities and pure random shocks) in Eq.(2.2.1) and (2.2.2) are normally distributed, then we can use the dynamic probit model to estimate the two equations. If we assume no restriction on the correlation between errors in the two equations, then Eq.(2.2.1) and (2.2.2) can be estimated as two dynamic univaraite probit models. Furthermore, if we assume that the errors are indeed correlated, then the two equations can be estimated together as a dynamic bivaraite probit model. One advantage of adopting a bivariate dynamic probit model is efficiency improvement. As long as there is no serial correlation, both univariate probit and bivariate probit give consistent estimators.

The challenge in estimating Eq.(2.2.1) and (2.2.2) is to handle the initial conditions problem in a dynamic, nonlinear model with unobserved heterogeneity. Due to the fact that our data is a short panel, we face the initial conditions problem. The conditional density of $(\mathbf{y}_1, \mathbf{y}_2, ..., \mathbf{y}_T)$ given $(\mathbf{y}_0, \mathbf{x}, \mathbf{c})$ is

$$
f(\mathbf{y}_1, \mathbf{y}_2, ..., \mathbf{y}_T | \mathbf{y}_0, \mathbf{x}, \mathbf{c}) = \Pi_{t=1}^{T} f_t(\mathbf{y}_t | \mathbf{x}_t, \mathbf{y}_{t-1}, \mathbf{c}; \Theta) \tag{2.2.3}
$$

which depends on unobserved heterogeneity, $\mathbf{c}$. We can maximize the likelihood specified in Eq.(2.2.4) over both $\mathbf{c}$ and Θ, so that the unobserved effects are treated as parameters to be estimated.

$$
\sum_{i=1}^{N} \sum_{t=1}^{T} lnf(\mathbf{y}_{it} | \mathbf{x}_{it}, \mathbf{y}_{i,(t-1)}, \mathbf{c}_i; \Theta) \tag{2.2.4}
$$

However, the Maximum Likelihood Estimators for Eq.(2.2.4) treats the initial condition as exogenous, which yields inconsistent estimates especially with a short panel. As pointed out in Heckman (1981), many researchers treated the initial condition problem "casually", by assuming the initial conditions and the pre-sample history of the process to be exogenous. However, this assumption can be easily and frequently violated if the disturbances are serially dependent. Estimates will be inconsistent if disturbances are indeed serially correlated. Heckman (1981) shows that if the analyst has access to the entire history of the process, then the maximum likelihood estimators treating the initial condition as non-stochastic are consistent if T $\rightarrow \infty$ and N $\rightarrow \infty$ or just N$\rightarrow \infty$. However, suppose that the analyst only has access to the latter part of the whole history, in this case, the "initial" state for each individual starts from time period 0, and cannot be treated as fixed or exogenous. Because this "initial" state is determine by the data generating process for the entire panel. Unless the distribution of individual unobserved heterogeneity $c_{j,i}$ is degenerate, in another word, all the $c'_{j,i}s$ are not serially dependent in the disturbance of the model $c_{j,i} + u_{j,it}$, the initial state $y_{j,i0}$ is not exogenous and is dependent on the individual unobserved random effect $c_{j,i}$. Under this circumstance, if we still maximize the likelihood function treating $y_{j,i0}$ as exogenous, the estimators are inconsistent.

The techniques of tackling the problem in a linear model have been widely developed. For example, we can use some transformation such as differencing to eliminate the unobserved effects. However, solving the initial conditions problem is more difficulty in nonlinear models. Wooldridge (2005) has proposed a method to model the distribution of the unobserved effect conditional on the initial value and any exogenous explanatory variables. More specifically, we need to find the density of $(\mathbf{y}_1, \mathbf{y}_2, ..., \mathbf{y}_T)$ conditional on $(\mathbf{y}_0,\ \mathbf{x},\ \mathbf{c})$. Together with the density of $(\mathbf{y}_1, ..., \mathbf{y}_T)$ conditional on $(\mathbf{y}_0, \mathbf{x}, \mathbf{c})$, we can obtain the density of $(\mathbf{y}_1, ..., \mathbf{y}_T)$ conditional on $(\mathbf{y}_0, \mathbf{x})$.

$$f(\mathbf{y}_1, ..., \mathbf{y}_T|\mathbf{y}_0, \mathbf{x}) = f(\mathbf{y}_1, ..., \mathbf{y}_T|\mathbf{y}_0, \mathbf{x}, \mathbf{c})f(\mathbf{c}|\mathbf{y}_0, \mathbf{x}) \tag{2.2.5}$$

The MLE for likelihood specified in Eq.(2.2.6) will yield consistent estimation results.

$$\sum_{i=1}^{N} ln\Pi_{t=1}^{T} f_t(\mathbf{y}_t|\mathbf{x}_t, \mathbf{y}_{t-1}, \mathbf{c}; \Theta)f(\mathbf{c}|\mathbf{y}_0, \mathbf{x}) \tag{2.2.6}$$

Another method to tackle the incidental parameter problem is provided by Heckman (1981). The main idea is to find the density of the initial condition given unobserved individual effects, and then integrate out the unobservables. There are two drawbacks in Heckman's approach. First, we need to be able to find an appropriate distribution of initial conditions given unobservables, $f(\mathbf{y}_0|\mathbf{x}, \mathbf{c})$. Second, it is computationally more difficulty than necessary for obtaining both parameter estimates and estimates of average effects in nonlinear models (Wooldridge (2005)). Therefore, this paper follows Wooldridge's methodology.

To specify the $f(\mathbf{c}|\mathbf{y}_0, \mathbf{x})$, Wooldridge (2005) considers a univariate case, in which the unobserved individual heterogeneities are assumed to be functions of y_{i0} and $\mathbf{x}_i$. $\mathbf{x}_i$ is the row vector of all (non-redundant) explanatory variables in all time periods.

$$c_i|y_{i0}, x_i \sim N(\xi_0 + \xi_1 y_{i0} + x_i\zeta, \sigma_\alpha^2) \tag{2.2.7}$$

In our bivariate model, we can make similar specifications on unobserved heterogeneities. Assume the conditional probability distribution of $c_{1,i}$ and $c_{2,i}$ to be:

$$c_{j,i}|y_{j,i0}, \mathbf{x}_i \sim N(\xi_{j,0} + \xi_{j,1} y_{j,i0} + \overline{\mathbf{x}}_i\zeta_j, \sigma_{\alpha_j}^2), \quad j = 1, 2 \tag{2.2.8}$$

Again, the $j = 1, 2$ refer to the equations on migration and non-farm business ownership respectively. $\overline{x}_i$ is the time average of some *time variant* explanatory variables. Of course, it is allowed to also include the time average of the *time invariant* explanatory variables, which will be just the variables themselves. In that case, we will not be able to identify the mechanism through which such variables affect the outcomes. For example, gender can affect the ultimate choices of migration/business directly, or it can contribute to the unobserved heterogeneity (say, males are more ambitious) and hence affects the choices indirectly.

Following Eq.(2.2.8), I can express the unobserved individual characteristics in terms of initial choices $y_{j,i0}$ and $\overline{x}_i$:

$$\begin{aligned} &[\text{Migration}] \quad c_{1,i} = \xi_{10} + \xi_{11} y_{1,i0} + \xi_{12} y_{2,i0} + \overline{\mathbf{x}}_i\zeta_1 + \alpha_{1,i} \\ &[\text{Non-farm}] \quad c_{2,i} = \xi_{20} + \xi_{21} y_{1,i0} + \xi_{22} y_{2,i0} + \overline{\mathbf{x}}_i\zeta_2 + \alpha_{2,i} \end{aligned} \tag{2.2.9}$$

If we plug the Eq.(2.2.9) into the original migration and non-farm business equations (2.2.1) and (2.2.2), the dynamic bivariate probit model becomes:

$$\begin{aligned} y_{1,it}^* &= \underbrace{y_{1,i(t-1)}\gamma_{11} + y_{2,i(t-1)}\gamma_{12}}_{\text{State Dependence}} + \mathbf{x}_{it}'\beta_1 + \underbrace{\xi_{10} + \xi_{11} y_{1,i0} + \xi_{12} y_{2,i0} + \overline{\mathbf{x}}_i\zeta_1 + \alpha_{1i}}_{\text{Unobserved Het. in terms of initial cond'n and RE}} + u_{1,it} \\ y_{2,it}^* &= y_{1,i(t-1)}\gamma_{21} + y_{2,i(t-1)}\gamma_{22} + \mathbf{x}_{it}'\beta_2 + \xi_{20} + \xi_{21} y_{1,i0} + \xi_{22} y_{2,i0} + \overline{\mathbf{x}}_i\zeta_2 + \alpha_{2i} + u_{2,it} \end{aligned} \tag{2.2.10}$$

Next, we need to specify our assumptions for the distributions of both $\alpha_i's$ and $u_{it}'s$. The first alternative is not to put any restrictions on correlations between α_{1i} and α_{2i}, and between $u_{1,it}$ and $u_{2,it}$. In this case, we assume that α_{1i} and α_{2i} are normally distributed $\alpha_{j,i} \sim N(0, \sigma^2_{\alpha_j}), j = 1, 2$. $u_{1,it}$ and $u_{2,it}$ are also normally distributed $u_{j,it} \sim N(0,1), j = 1, 2$. Then we can estimate the migration and business equations by two separate univariate probit. The second alternative is to assume that α_{1i} and α_{2i}, $u_{1,it}$ and $u_{2,it}$ are both bivariate normally distributed.

$$\begin{pmatrix} \alpha_{1,i} \\ \alpha_{2,i} \end{pmatrix} \sim N\left(\mathbf{0}_{2\times 1}, \begin{bmatrix} \sigma^2_{\alpha_1} & \rho_\alpha \\ \rho_\alpha & \sigma^2_{\alpha_2} \end{bmatrix}\right)$$

$$\begin{pmatrix} u_{1,it} \\ u_{2,it} \end{pmatrix} \sim N\left(\mathbf{0}_{2\times 1}, \begin{bmatrix} 1 & \rho_u \\ \rho_u & 1 \end{bmatrix}\right)$$

The time variant random error terms $u_{1,it}$ and $u_{2,it}$ are assumed to be bivariate normally distributed with zero means, and both of their variances are normalized to one. The correlation coefficient between u_1 and u_2 is ρ_u. In panel data analysis, we should be aware that the errors are potentially heteroskedastic and/or serial correlated (Cameron and Trivedi(2005)). Therefore, we use panel bootstrap method to correct for heteroscedasticity in univariate probit estimation. The bootstrap method can be applied to as long as observations are independent over individuals (i) and N $\to \infty$. Even though it is also crucial to correct standard errors for serial correlation in errors at the individual level, computer packages currently do not automatically do this.

To make our denotation more concise, let us use $\mathbf{w}_{it}$ to represent all the regressors for individual i and period t:

$$\mathbf{w}_{it} = [y_{1,i(t-1)}, y_{2,i(t-1)}, \mathbf{x}_{it}, 1, y_{1,i0}, y_{2,i0}, \overline{\mathbf{x}}_{\mathbf{i}}] \qquad (2.2.11)$$

The set of coefficients for regressors in equation j can be expressed by Θ_j:

$$\Theta_j \equiv [\gamma_{j1}, \gamma_{j2}, \beta_j', \xi_{j0}, \xi_{j1}, \xi_{j2}, \zeta_j]', \qquad j = 1, 2 \qquad (2.2.12)$$

In addition to regression coefficients, we also need to estimate the variances and correlation coefficients of the two random effects and pure random errors. Thus, we can use Λ to represent the set of all parameters to be estimated in this paper.

$$\Lambda \equiv [\Theta_1', \Theta_2', \sigma_{\alpha_1}^2, \sigma_{\alpha_2}^2, \rho_\alpha, \rho_u]' \tag{2.2.13}$$

The density function for an observation i in period t given the random effects can be written as:

$$\begin{aligned} & f(y_{1,it}, y_{2,it}|\mathbf{w_{it}}, \Theta_1, \Theta_2, \alpha_{1,i}, \alpha_{2,i}) \\ & = \Phi[q_{1,it}(\mathbf{w}_{it}\Theta_1 + \alpha_{1,i}), q_{2,it}(\mathbf{w}_{it}\Theta_2 + \alpha_{2,i}); q_{1,it}q_{2,it}\rho_u] \end{aligned} \tag{2.2.14}$$

The joint conditional density function for individual i in all periods is then given by:

$$\begin{aligned} & \Pi_{t=1}^T f(y_{1,it}, y_{2,it}|\mathbf{w}_{it}, \Theta_1, \Theta_2, \alpha_{1,i}, \alpha_{2,i}) \\ & = \Pi_{t=1}^T \Phi[q_{1,it}(\mathbf{w}_{it}\Theta_1 + \alpha_{1,i}), q_{2,it}(\mathbf{w}_{it}\Theta_2 + \alpha_{2,i}); q_{1,it}q_{2,it}\rho_u] \end{aligned} \tag{2.2.15}$$

$\Phi()$ is the cumulative density function for standard normal distribution, and

$$q_{j,it} = 2y_{j,it} - 1, \quad j = 1, 2 \tag{2.2.16}$$

We can integrate out the random effects α_{1i} and α_{2i} in Eq.(2.2.15) to obtain the likelihood function for individual i:

$$\begin{aligned} & \ell_i(\Lambda) = f(y_{1,i}, y_{2,i}|\mathbf{w}_{it}, \Lambda) \\ & = \int_{\alpha_1}\int_{\alpha_2} \Pi_{t=1}^T \Phi[q_{1,it}(\mathbf{w}_{it}\Theta_1 + \alpha_{1,i}), q_{2,it}(\mathbf{w}_{it}\Theta_2 + \alpha_{2,i}); q_{1,it}q_{2,it}\rho_u] f(\alpha_1, \alpha_2) d\alpha_1 d\alpha_2 \end{aligned} \tag{2.2.17}$$

Assuming independence over i, the likelihood function for all individuals is then given by:

$$L_N(\Lambda) = \Pi_{i=1}^N \ell_i(\Lambda), \tag{2.2.18}$$

and the log-likelihood function for all individuals in all periods can be written as:

$$\ln L_N(\Lambda) = \sum_{i=1}^N \ln \ell_i(\Lambda) \tag{2.2.19}$$

2.2.1 Maximum Simulated Likelihood Estimation

Since no analytical expression is available for the likelihood function (2.2.17), we need to consider the maximum simulated likelihood (MSL) method. A simulator for $f(y_{1,i}, y_{2,i}|\mathbf{w}_{it}, \Lambda)$

in (2.2.17) is a Monte Carlo estimate

$$\hat{f}(y_{1,i}, y_{2,i}|\mathbf{w}_{it}, \Lambda, \alpha_1, \alpha_2) = \frac{1}{S}\sum_{s_1=s_2=1}^{S} \tilde{f}(y_{1,i}, y_{2,i}|\mathbf{w}_{it}, \Lambda, \alpha_1^{s_1}, \alpha_2^{s_2}) \tag{2.2.20}$$

where $\alpha_1^{s_1}, \alpha_2^{s_2}$ are S pairs of draws, but they are not necessarily independent over s (Cameron and Trivedi(2005)). When the subsimulator $\tilde{f}()$ is an unbiased simulator, the simulator $\hat{f}_i \to f$ in probability as $S \to \infty$. Given independence over i, the maximum simulated likelihood (MSL) estimator $\hat{\Lambda}_{\text{MSL}}$ maximizes the log-likelihood based on a simulated estimate of the density, or

$$\ln\hat{L}_N(\Lambda) = \sum_{i=1}^{N} \ln\hat{\ell}_i(\Lambda) = \sum_{i=1}^{N} \ln\hat{f}(y_{1,i}, y_{2,i}|\mathbf{w}_{it}, \Lambda, \alpha_1^{s_1}, \alpha_2^{s_2}) \tag{2.2.21}$$

Gourieroux and Monfort (1991) shows that the maximum simulated likelihood estimator is asymptotically equivalent to the ML estimator if S, N $\to \infty$ and $\sqrt{N}/S \to 0$, and it has a limit normal distribution with

$$\sqrt{N}(\hat{\Lambda}_{\text{MSL}} - \Lambda_0) \to^d \quad N[0, A^{-1}(\Lambda_0)] \tag{2.2.22}$$

where

$$A(\Lambda_0) = -\text{plim}\Big[N^{-1}\sum_{i=1}^{N} \frac{\partial^2 lnf(y_{1,i}, y_{2,i}|\mathbf{w}_{it}, \Lambda)}{\partial\Lambda\partial\Lambda'}\Big|_{\Lambda_0}\Big] \tag{2.2.23}$$

The consistency of the MSL estimator can be achieved when S, N $\to \infty$. However, the MSL estimator is not fully efficient unless $\sqrt{N}/S \to 0$. In other words, the number of draws S must increase with sample size at a faster rate than $\sqrt{N}$. The optimization is conducted through MaxBFGH in Ox 5.10 (Doornik 2007).

2.2.2 Average Partial Effects

In non-linear models, coefficients of regressors do not have a direct interpretation as the marginal effect. For example, in the probit model, $E[y|x] = \Phi(x'\beta)$, then $\partial E[y|x]/\partial x = \phi(x'\beta)\beta$, which is a function of both parameters and regressors. Therefore, it helps to calculate some forms of marginal effects, such as Average Partial Effects (APE). The objective of this section is to determine the marginal effect of change in a regressor on the conditional probability that $y = 1$. The major challenge lies in what value should be assigned to the "unobserved individual effects". Wooldridge (2005) solved this problem by integrating the target function over the distribution of the random effects. In our model, let us denote this "partial effect" in equation j by $m_j(\tilde{\mathbf{x}}_t, \tilde{\mathbf{y}}_{t-1}, \mathbf{c}; \hat{\Theta})$, in which, $\tilde{x}$ can be certain values such as mean or some representative values. We integrate the function $m(;)$ over the distribution of unobserved individual characteristics, c, so there is no need to worry about assigning values to it.

$$m_j(\tilde{\mathbf{x}}_t, \tilde{\mathbf{y}}_{t-1}, \mathbf{c}; \hat{\Theta}) = E[Pr\{y_{j,it} = 1 | \mathbf{x}_{it} = \tilde{\mathbf{x}}_{it}, \mathbf{y}_{i(t-1)} = \tilde{\mathbf{y}}_{i(t-1)}, c_{ji}\}] \tag{2.2.24}$$

According to Law of Iterated Expectations,

$$\begin{aligned}
&E[m_j(\tilde{\mathbf{x}}_t, \tilde{\mathbf{y}}_{t-1}, \mathbf{c}; \hat{\Theta}] \\
&= E[E[m_j(\tilde{\mathbf{x}}_t, \tilde{\mathbf{y}}_{t-1}, \mathbf{c}; \hat{\Theta})|\mathbf{c}]] \\
&= E[E[Pr\{y_{j,it} = 1 | \mathbf{x}_{it} = \tilde{\mathbf{x}}_{it}, \mathbf{y}_{i(t-1)} = \tilde{\mathbf{y}}_{i(t-1)}, c_{ji}\}|c]] \\
&= E[\int Pr\{y_{j,it} = 1 | \mathbf{x}_{it} = \tilde{\mathbf{x}}_{it}, \mathbf{y}_{i(t-1)} = \tilde{\mathbf{y}}_{i(t-1)}, c_i\} f(c|\mathbf{y}_{i0}, \tilde{x}_{it}) f(c) dc] \\
&= E[\int Pr\{y_{j,it} = 1 | \mathbf{x}_{it} = \tilde{\mathbf{x}}_{it}, \mathbf{y}_{i(t-1)} = \tilde{\mathbf{y}}_{i(t-1)}, \mathbf{y}_{i0}\} f(\alpha) d\alpha] \\
&= E[\int \Phi(\tilde{y}_{1,i(t-1)}\hat{\gamma}_{j1} + \tilde{y}_{2,i(t-1)}\hat{\gamma}_{j2} + \tilde{\mathbf{x}}'_{it}\hat{\beta}_j + \hat{\xi}_{j0} + \hat{\xi}_{j1} y_{1,i0} + \hat{\xi}_{j2} y_{2,i0} + \overline{\mathbf{x}}_i \hat{\zeta}_{j1} + \alpha_{ji}) f(\alpha) d\alpha]
\end{aligned} \tag{2.2.25}$$

In the bivariate probit model specified in this paper, we can use sample mean of $m()$ to approximate $E[m()]$, for both equations:

$$\begin{aligned}
&\hat{m}_j(\tilde{\mathbf{x}}_t, \tilde{\mathbf{y}}_{t-1}, \mathbf{c}; \hat{\Theta}) \\
&= N^{-1} \sum_{i=1}^{N} \Phi(\tilde{y}_{1,i(t-1)}\hat{\gamma}_{j1} + \tilde{y}_{2,i(t-1)}\hat{\gamma}_{j2} + \tilde{\mathbf{x}}'_{it}\hat{\beta}_j + \hat{\xi}_{j0} + \hat{\xi}_{j1} y_{1,i0} + \hat{\xi}_{j2} y_{2,i0} + \overline{\mathbf{x}}'_i \hat{\zeta}_{j1} + \alpha_{ji}) \\
&= N^{-1} \sum_{i=1}^{N} \Phi(\tilde{y}_{1,i(t-1)}\hat{\hat{\gamma}}_{j1} + \tilde{y}_{2,i(t-1)}\hat{\hat{\gamma}}_{j2} + \tilde{\mathbf{x}}'_{it}\hat{\hat{\beta}}_j + \hat{\hat{\xi}}_{j0} + \hat{\hat{\xi}}_{j1} y_{1,i0} + \hat{\hat{\xi}}_{j2} y_{2,i0} + \overline{\mathbf{x}}'_i \hat{\hat{\zeta}}_{j1})
\end{aligned} \tag{2.2.26}$$

where $\hat{\hat{b}} = \hat{b}/\sqrt{\hat{\sigma}_\alpha^2 + 1}$.

Then the APE can be calculated by taking derivative of Eq.(2.2.26) with respect to the variable that we are interested in. We need to be cautious when there are both discrete and continuous variables. For variables that are discrete, such as $y_{1,i(t-1)}$, the APE can be calculated by:

$$N^{-1}\sum_{i=1}^{N}[\Phi(1*\hat{\hat{\gamma}}_{j1}+\tilde{y}_{2,i(t-1)}\hat{\hat{\gamma}}_{j2}+\tilde{\mathbf{x}}'_{it}\hat{\hat{\beta}}_{j}+\hat{\hat{\xi}}_{j0}+\hat{\hat{\xi}}_{j1}y_{1,i0}+\hat{\hat{\xi}}_{j2}y_{2,i0}+\overline{\mathbf{x}}'_{i}\hat{\hat{\zeta}}_{j1}) \\ -\Phi(0*\hat{\hat{\gamma}}_{j1}+\tilde{y}_{2,i(t-1)}\hat{\hat{\gamma}}_{j2}+\tilde{\mathbf{x}}'_{it}\hat{\hat{\beta}}_{j}+\hat{\hat{\xi}}_{j0}+\hat{\hat{\xi}}_{j1}y_{1,i0}+\hat{\hat{\xi}}_{j2}y_{2,i0}+\overline{\mathbf{x}}'_{i}\hat{\hat{\zeta}}_{j1})] \tag{2.2.27}$$

For continuous variables such as fraction of male family members, the APE can be calculated by:

$$N^{-1}\sum_{i=1}^{N}[\phi(\tilde{y}_{1,i(t-1)}\hat{\hat{\gamma}}_{j1}+\tilde{y}_{2,i(t-1)}\hat{\hat{\gamma}}_{j2}+\tilde{\mathbf{x}}'_{it}\hat{\hat{\beta}}_{j}+\hat{\hat{\xi}}_{j0}+\hat{\hat{\xi}}_{j1}y_{1,i0}+\hat{\hat{\xi}}_{j2}y_{2,i0}+\overline{\mathbf{x}}'_{i}\hat{\hat{\zeta}}_{j1})\hat{\hat{\beta}}_{j}] \tag{2.2.28}$$

where $\phi()$ is the probability density function for standard normal distribution.

2.3 The Data Description

This paper uses the China Rural Households Survey data collected by the Research Center for Rural Economy (RCRE), a research institute in the Agricultural Ministry of China. The RCRE survey data set is the only empirical source for research on rural China that possesses three features at the same time: first, it was collected and managed by one of the most reputable research authorities in China; second, on the time dimension, it covers as long as 11 years from 1984 to 1999[1]; third, on the geographic dimension, it surveyed 10 provinces, which resulted in a rich data set containing 37422 households.

For the empirical study of this paper, we make use of the RCRE data set from 1995-99. We chose this segment of data for two reason: first, the time frame accommodates the goal of our empirical tests. Even though rural-urban migration and rural non-farm business began developing in early 1980s, both experienced fast growth in the latter part of 1990s. The second important reason is that, the RCRE survey was not conducted in 1994 due to lack of funding. This induces discontinuities in several dimensions of the data set as well as the attrition problem of surveyed households. For these two reasons, we focus on the data during 1995-99.

[1]China Rural Households Survey continues from 2000-2003. However, the pool of households in that survey are significantly different from the ones before 2000, and the total number of households has decreased.

The total number of households participating in the survey in at least one of the five years from 1995-99 is 9329. We deleted 721 observations with no data entry for total number of labor. We also dropped 16 observations with entry errors. 66 observations were eliminated because of missing records for the education level or the number of male family members. After cleaning the data, we were left with 9178 households, among which, only 5626 households participated in the RCRE survey for *all* five years. These 5626 households compose the sample data set that we apply empirical methods to.

Rural households in China derive their income mainly from three sources: farm sector, non-farm sector, and migration work. Farm sector work includes growing crops, planting forests, fishing, and keeping animals. Non-farm sector include manufacturing (including agricultural product processing), construction, transportation, retailing, lodging and restaurants, and other services. The RCRE survey does not provide direct information on whether a rural household mainly engaged in farm or non-farm work, therefore we need to provide a precise definition for rural farm households and non-farm households. We have at least two options: first, we can categorize rural households into farm and non-farm according to their income level. Under this definition, if a rural household earns most of its income from farm sector jobs, then it is a "farm" household. Similarly, we can also define "non-farm" households. Our second option is, instead of using income, we can define rural household employment types by their time allocation. Under such definition, if a rural household spends more time on farm work, then it is a "farm" household. Comparing the two options of definition, even though the second one seems to be a more natural approach, unfortunately, information on the allocation of time for different jobs are not available in the RCRE data set. Therefore, the first definition is adopted in this paper. Table 6 illustrates that from 1995 to 1999, the percentages of rural households who owned non-farm business increased steadily from 19.32% to 26.04%, and that of farm households had decreased from 80.68% to 73.95%. Once again, let me make it clear about the terminology here: "rural households" refer to all the households in this rural households survey; "farm households" refers to the rural households who mainly engage in working in farm sector; "non-farm households" refers to the rural households who mainly engage in working in non-farm sector.

Since this is a survey at the household level, for those households who have remittances from migrating household members, it is possible that only some family members migrated. Therefore, both farm and non-farm households may have migration remittances, if only some family members migrated. The fourth column in Table 7 shows that the proportion of households who had remigttances from migration increased from 40.43% in 1995, to 47.67% in 1999. This reflects the increasing number of households participated in migration activities and received migration remittances during this five years.

Even though Table 6 gives us an overview of farm and non-farm households composition, it will be helpful to know the proportion of households transferring into and from both sectors. The results of panel transition matrix are displayed in Table 8, which presents the transition of rural households between farm and non-farm sectors. Although the proportion of households switched from farm sector jobs into non-farm sector jobs is 8.72%, which was smaller than the proportion of households transited from non-farm sector jobs into farm sector jobs, 24.14%, however, given the large initial number of farm households, there was still net increase of non-farm households.

Table 9 presents the summary statistics of demographic characteristics in the rural households survey. "Education" records the percentages of households members that had no education at all (0 year), or had elementary school education (6 years), or had secondary education (9 years) or had high school and above ($>$ 9 years). The education level in general was still quite low in rural China during the survey period. 15.29% of the surveyed households did not have any kind of education at all, 40.06% only finished elementary school, 37.08% had middle school education, while only 7.55% went to high school.

Table 10 displays the summary statistics for production assets, revenue and income. We find large income inequalities between the farm and non-farm households. Farm households obtained most of their income from farm sector jobs, and their average annual income was 1827.64 yuan (equivalent to 219.63 US dollars during 1995-99). Non-farm households earned most of their income from the non-farm sector jobs, and their average annual income was 4454.42 yuan (equivalent to 535.29 US dollars during 1995-99). Thus non-farm households earned about 2.39 times that of farm households. Furthermore, non-farm households earned larger income from migration activities, 1268.92 yuan (equivalent to 152.48 US dollars during 1995-99), 46.64% higher than the migration remittances received by farm households.

We also examined the correlation among incomes from different sources. Table 11 shows that the farm income was negatively correlated with both non-farm and migration remittances; however, the non-farm income and migration remittances was positively correlated. The correlation coefficients primarily echo our presumption on the interactions between the non-farm business and migration.

2.4 Estimation Results

2.4.1 Estimation Results for the Univariate Probit Model

If we impose no constraints on the random effects from equations (2.2.1) and (2.2.2), we can estimate these two equations separately through univariate probit model. The estimation results are presented in Table 12. There is evidence for state dependence between period $(t-1)$ and t. If a household received migration remittances in the previous period, then it is more likely to keep receiving migration remittances in the current period as the estimated coefficient is 0.8583 (Table 12, row 2). If a household was in the rural non-farm business in the previous period, then it is also more likely to stay in business in the current period as the estimated coefficient is 1.0410 (Table 12, row 3). Households possess specific skills granting them comparative advantage in different sectors, therefore rural agents prefer continuity and stability in occupational choices to frequent employment changes.

The estimated coefficient of the education level is 0.1084 in the migration equation and 0.0977 in the non-farm business equation, both significant (Table 12, row 4). Our results support that education continues to play a crucial role in China's rural development. Households equipped with higher human capital, more knowledge and skills seem to be more active in seeking employment outside farm sector. The more diverse job opportunities such as migrating to cities and work for the urban production sector, or operating rural non-farm business provide better educated households with wider income sources.

Male proportion also increases the likelihood of a household receiving migration remittances, as suggested in the estimated coefficient 0.1510 (Table 12, row 5). This result is consistent with the rural-urban migration reality in China. Rural migrants usually travel long distance from inland provinces such as Sichuan, Hubei, Henan to coastal cities abound with job opportunities. Young male migrants tend to adapt to relocation and new environment faster than female rural migrants. Therefore, rural households with higher proportion of male family members are more likely to have income from migration activities. The coefficient of male fraction in the non-farm business equation is also positive but with a high standard error of 0.0766 (Table 12, row 5). Therefore we cannot reject the hypothesis that male fraction has no effect on non-farm business operation at the significance level of 5%.

There is evidence that the number of labor in a household increases the likelihood of migration and hence receiving migration remittances, as suggested by the estimated coefficient of 0.2493 (Table 12, row 6). After the economic reform promoted rural farm productivity, many families, especially big families, found themselves with labor surplus. The labor surplus formed the later strength of rural-urban migrants class. Therefore, it is expected to have a positive estimate for the variable number of labor in the migration equation.

The estimated coefficient of (log transformed) production assets in the previous year in the migration equation is -0.0215, negative and significant (Table 12, row 7). On the other side, the corresponding coefficient in the non-farm business equation is 0.0185, positive and significant (Table 12, row 7). This illustrates that if a household possesses enough assets for rural production, regardless farm or non-farm production, it is more likely to allocate both labor and time to rural production rather than to migration work. Our estimation shows that the variable location is important in determining migration remittances and non-farm business operation.

The coefficient of the dummy variable location is 0.0883 in the migration equation, and 0.4477 in the non-farm equation, both are significant (Table 12, row 9) . Since a large number of manufacturing and exporting factories settle in costal cities, individuals from rural areas nearby have easier access to migration in terms of transportation. In addition, rural agents from areas closer to costal cities also face smaller regional differences and less psychological difficulties (such as homesickness) when they migrate to these urban sectors. On the other hand, the proximity of rural areas to costal cities generates positive externality in terms of better quality of infrastructure and schools. The development of urban sectors create spillovers for the neighboring regions. Therefore, being in costal provinces raises the chance for rural households to enter the non-farm business.

Our estimation also support the hypothesis that initial status of rural households affect their later employment status. The coefficient of whether or not a household received migration remittances in the first period (1995 for our chosen sample data set) is 1.1260 in the migration equation and -0.0943 in the non-farm business equation, both significant (Table 12, row 11). On the other side, the coefficient of whether or not a household was in rural non-farm business in the first period is -0.1254 in the migration equation and 1.3800 in the non-farm equation, also both significant (Table 12, row 10). Over the five years time frame that our study focuses on, rural households had the tendency of continuing their status in 1995. In other words, if a household was receiving migration remittances in 1995, then it is more likely to keep receiving remittances in the following years. And if a household was already in non-farm business, then it tended to stay in the same sector later. We expect this result given the sample data has a relatively short time range of only five years. The longer the time frame, the less influences the initial conditions have on the later periods.

2.4.2 Estimation Results for the Bivariate Probit Model

In the last subsection, we analyze the estimation results from two separate univariate probit model. We can extend the univariate probit model to a bivariate probit model by assuming that the random effects in both equations, α_1 and α_2 are correlated through ρ_α. And we assume the pure random shocks in both equations, $u_{1,it}$ and $u_{2,it}$, are correlated through ρ.

By examining results from the bivariate probit model and univariate probit model, we find that the log-likelihoods for the two univariate probit regressions are -10350.26 and -7395.63, thus the sum is -17745. The log-likelihood of the bivariate probit regression is -17696.6. Therefore the bivariate probit regression possesses a higher log-likelihood than the univariate probit regression.

Comparing estimated coefficients in Table 13 and Table 12, we find that estimators are similar in terms of signs and standard errors. However, coefficients of the four state dependence effects are under estimated in the univariate probit model in terms of absolute values. Coefficients of education, male fraction, number of labor, production assets, location, and initial conditions are slightly over estimated by amounts from 0.01 to 0.07 in the univariate probit model.

We are interested in the state dependence effects from lagged to current migration remittances, and from lagged to current non-farm business operations. In addition, we would also like to examine the cross dependence effects from lagged migration remittances to current non-farm business, and from lagged non-farm business to current migration remittances. The state dependence coefficient is estimated to be 0.9630 in the migration equation, and 1.2974 in the non-farm business equation (Table 13, rows 2 and 3). The estimation from bivariate probit model also supports that rural households have strong tendency of continuing their status from the previous period. As mentioned above, households make occupational choices according to their specific skills. The learning cost of adopting new skills convinces people to remain in certain sectors rather than frequently switch jobs. The cross dependence coefficient is -0.2544 in the migration equation and -0.1794 in the non-farm business equation (Table 13, rows 3 and 2). The time and labor constraints facing rural households explain why the lagged migration remittances status has negative effect on current business ownership status, and why the lagged business ownership status has negative effect on current migration remittances status. The total time and labor available for households are both limited. For household members who migrated and worked in cities, they contributed less or even zero time and labor to production in rural hometown. If some household members had already engaged in migration activities in $(t-1)$, they had paid sunk cost related with migration, such as transportation cost, job searching cost, housing, etc. Therefore, it is reasonable for them to stay in cities as a migrant worker in the following periods. Likewise, if some household members had entered the rural non-farm business in the previous period, it is more likely that they would remain in the non-farm business.

The estimation for demographic characteristics, such as education, male fraction in the family, and number of the labor in households are consistent with our expectation. The coefficient of education is 0.0993 in the migration equation, and 0.0912 in the non-farm business equation, both significant (Table 13, row 4). The result again supports our hypothesis that education and human capital promote the likelihood of receiving income from migration and operating rural non-farm business. As explained in the data description section, the education variable measures the weighted average education level in the household. Liu (2009) argues that rural agents who possess higher human capital are more likely to migrate to cities as well as to operate rural non-farm business. In contrast, those with lower human capital are more likely to work in farm production sector. Therefore, the empirical study in this paper supports the theoretical model in Liu (2009). The coefficient of male fraction is 0.1462 in the migration equation, and 0.0669 in the non-farm equation, even though it is insignificant in the latter one (Table 13, row 5). The coefficient of number of labor is 0.2319 in the migration equation (Table 13, row 6), which again justifies our presumption that families with labor surplus have a higher tendency of migration and hence receiving migration remittances.

The coefficient of (log transformed) production assets from the previous period is -0.0188 in the migration equation, and 0.0130 in the non-farm business equation, both significant. This shows that families with more production assets in rural areas are less likely to pursue migration activities, and hence less likely to receive income from migration. On the other hand, production assets are crucial in determining whether or not a household is in the non-farm business. We use the assets from the previous period in order to avoid endogeneity problem. Rural non-farm business has higher return than farm production, however, it also requires more investment input. The credit market in rural areas in China was not mature in late 1990s. Therefore, rural agents who plan to enter non-farm business mostly relied on borrowing from relatives and friends for investment funds. The production asset and deposit from $(t-1)$ can be viewed as an imperfect instrument for the households' asset holding. Families with low income face difficulties in raising fund and purchasing production assets, which creates a barrier for them to start non-farm business. If the goal of government is to promote the development of rural non-farm sectors, an effective way is to provide low-income families with necessary production assets through loans or lending, so that they are able to get over the initial hurdle.

Similar with results from the univariate probit model, the estimated coefficients for the dummy variable "coastal areas" are positive and significant in both equations. The estimate is 0.0851 in the migration equation, and 0.3755 in the non-farm business equation (Table 13, row 9).

The last coefficients estimation are the effects of the initial conditions on both migration remittances and non-farm business operation in later periods. The coefficient of whether or not a household received migration remittances in 1995 is 0.9669 in the migration equation (Table 13, row 10). And the coefficient of whether or not a household was in the non-farm sector in 1995 is 0.9592 in the non-farm business equation (Table 13, row 11).

The standard deviation of random effects, α are estimated to be 0.6886 and 0.5777 in the bivariate probit model (Table 13, row 12), both lower than the results in the univariate case. The over estimated values for standard deviations of random effects in univariate probit model can be attributed to its ignorance of the correlation between individual effects α_1 and α_2. We have normalized the standard deviation of the pure random shocks u_{1i} and u_{2i} to one. Therefore, 32.18% of total error component variance in the migration regression can be explained by variation in random effect α_{1i}; similarly, 25.02% of the total error component variance in the business regression can be explained by variation in random effect α_{2i}. In addition, the two random effects are correlated through ρ_α, which is estimated to be 0.2450 and significant. The significant correlation estimate supports the existence of unobserved characteristics affecting both migration remittances and non-farm business operation. For example, ambitious and diligent households are more likely to migrate as well as to start own businesses. Moreover, if some family members migrate while others stay in rural hometown, their communications on new technologies, information and knowledge can generates spillover effects from those who migrate to those who stay. By taking into account the correlation between these unobserved random effects, the bivariate probit model provides us more efficient estimates.

2.4.3 Estimation Results for Average Partial Effects (APE)

The estimation for Average Partial Effects is included in Table 14. While holding other variables at their mean values, APE measures the contribution of a marginal change in a variable of interest. We can draw several conclusions from the APE estimation results: first, if a household's state in receiving migration remittances in $(t-1)$ changes from 0 to 1, while all other variables are kept at their mean value, then the likelihood of the household receiving remittances in t is 0.2647 higher (Table 14, row 1). If a household operated rural non-farm businesses in $(t-1)$, then its chance of staying in non-farm business in period t increases by 0.2355 (Table 14, row 2). Second, the initial conditions are very crucial to the current state. Given a household had migration remittances in the first year in our data set, 1995, the likelihood of them continuing to have migration remittances in the following years is 0.3643 higher, while the likelihood of them operating rural non-farm business in the following years is 0.0137 lower (Table 14, row 3). On the other hand, if a household operated non-farm business in 1995, its likelihood of remaining in business is 0.3552 higher and its likelihood of having migration remittances is 0.0311 lower (Table 14, row 4. Fourth, education and male fraction both increase the odds of receiving migration remittances as well as operating rural non-farm business. The APE estimates of education are .0269 and .0141 in migration and non-farm business equations; and that of male fraction are 0.0374 and 0.0117 in the two equations respectively. Fifth, the APE estimates of production assets and deposit in the migration equation are both negative, which suggests that a higher level of asset holding reduces the likelihood of receiving migration remittances. On the contrast, the APE estimate of production assets in the business equation is positive, which shows that the more production asset a household possesses, the more likely it is in the non-farm business. Lastly, being in the coastal area provides a big advantage for households to operate rural non-farm business. Other things kept constant, if a household is from coastal area, their likelihood of operating rural non-farm business is 0.0725 higher (Table 14, row 10).

2.5 Conclusion

This paper provides an empirical study on the joint determination of receiving income from migration activities and operating rural non-farm business in China. In order to identify the genuine state dependence from the spurious one, this paper adopts a dynamic bivariate probit model with unobserved heterogeneities.

We set up the model following Wooldridge (2005). The heterogeneities are expressed in terms of initial conditions, time invariant variables, as well as unobserved random effects. In order to accommodates the common observations on interactions between migration remittances and rural non-farm business ownership, we assume random effects from the two dimensions are correlated. Due to the non-linearity of the model, we also compute the average partial effect (APE). APE measures the impacts of a marginal change in the variable of interests, while holding other variables at mean values.

We apply the empirical method to the China Rural Households Survey collected by the Research Center for Rural Economy (RCRE), a research institute in the Agricultural Ministry of China. Due to the attrition problem and data discontinuity problem in 1994 in the original survey, we used data during 1995-99 from RCRE survey. Our sample is composed of 5626 rural households over the five years span.

Several findings in this paper emerge. First, both state dependence and cross dependence effects are significant and strong. There are positive state dependence effect from lagged migration remittances to current migration remittances, and from lagged business ownership to current business ownership. In contrast, the cross dependence effect from lagged migration remittances to current business ownership is negative, and vice versa. This can be explained by the time and labor constraints facing rural households. Second, the education level of households has a positive effect on the likelihood of both receiving migration remittances and operating rural non-farm business. Due to large labor surplus in rural areas, it is crucial for the Chinese government to effectively encourage rural agents to seek employment opportunities outside the farm production sector. Our estimation results suggest that if we can promote education and per-capita human capital in rural area, rural agents will enjoy more opportunities to participate in migration and rural non-farm business. The third finding is that rural households with more production assets in the previous period are more likely to operate rural non-farm business. This suggests that if the Chinese government further reforms the financial market by making credits more accessible to rural individuals, many low-income rural households can get over the initial capital constraints and start their non-farm business. The fourth finding is that, rural households from the coastal areas have advantages in receiving migrate income as well as operating non-farm business. The proximity to costal cities not only alleviates difficulties during transportation, but also creates spillover effects for the nearby rural areas. The fifth and final point is that, the random effects from two dimensions—receiving migration remittances and operating non-farm business—are significantly positively correlated. Thus, there exist some unobserved characteristics that influence both status at the same time, such as family ambition, diligence, networks.

CHAPTER III

TEACHER ABSENTEEISM, HUMAN CAPITAL AND GROWTH IN DEVELOPING COUNTRIES (WITH GERHARD GLOMM)

3.1 Introduction

This paper analyzes the teacher absenteeism phenomenon and growth effects of government policies aiming to tackle this problem. School teachers make choices of absent length, given the expected value of financial penalty. Government finances the higher education with tax revenue and monitors school teachers. To curb teacher absence, government considers three policy instruments together: the labor tax rate, the teacher wages, and the financial penalty on teacher absenteeism. This paper studies the short-run and long-run effects of several policy combinations on teacher absenteeism, human capital, physical capital and economic growth.

Developing countries cannot ensure that they catch up in the global competition unless they grapple with problems and opportunities of education and human capital. The Millennium Development Goals call for substantial effort in the education sector of less developed countries by 2015. The literature in growth and development focuses on the areas such as public investments in technology, public funding for education at various levels, etc. Although these are all very important issues, success also hinges on adopting correct policies within education sectors. Such policies concern how schools make use of public funding efficiently, how to improve education quality, how to provide effective motivation for school administrators and teachers, and other issues. Many developing countries are in a very dire situation vis-à-vis the school teacher performance. In 2004, the World Bank launched the Absenteeism of Teachers and Social Workers Survey in developing countries, as part of the World Development Report 2004: Making Services Work for the Poor. In each state of every country in the survey, the Bank's team investigated 10 districts, with at least two visits to a representative sample of at least 10 or more primary schools within each. The outcomes were very disappointing. From Bangladesh to Indonesia to Ecuador, from India to Peru to Uganda, an average 15 percent of teachers were absent in schools during the survey period. Through the compelling survey data, the World Bank's report spotlights the issue which has been shrugged off for quite a long time. Chaudhury, et al. (2006) admit that "the research results provide only tentative guidance on how to reduce absence." Hence, a theoretical framework needs to be constructed to facilitate our understanding of the issue.

This paper has two objectives. First, we formulate an analytical model to describe the teacher absenteeism phenomenon in developing countries. We examine interactions between private agents in a general equilibrium setting. Second, through calibrating and simulating the model, we are able to recognize the economic implications of teacher absenteeism on both the short-run and the long-run economic growth, and to estimate effects of certain policy reforms. We find that policies have mixed effects depending on policy regimes. In contrast to the conventional wisdom that a lower teacher absenteeism can boost the economic growth, this paper shows that the results in fact hinge on different parameters and the initial conditions; thus reducing teacher absenteeism abruptly may decrease GDP and the economic growth in the short run.

The paper is organized as follows. Section two describes the model. Section three solves the model. Section four and five defines competitive equilibrium and balanced growth paths. Section six simulates the model under calibrated parameter values, and conducts three policy experiments. Section seven concludes.

3.2 The Model

In an overlapping generations (OLG) model, individuals live for three periods—childhood (period 0), adulthood (period 1) and retirement (period 2), with each period accounting for 25 years. We normalize the total population to one and assume no population growth. Every child is born to be the same in his cohort. A fraction $\underline{\pi}$ of children only receive basic education, comprising primary education and secondary education, and a fraction $\overline{\pi} = 1 - \underline{\pi}$

of children continue to receive higher education afterwards. Among those who accomplish the higher education, a proportion ζ become school teachers, and the remaining $(1-\zeta)$ become high-skilled workers employed in the production sector. Therefore, private agents are heterogenous in their human capital level at the end of childhood. The economy has three types of *adult* agents: low-skilled workers, high-skilled workers and school teachers:

$$1 = \underbrace{\pi}_{\text{Low-skilled workers}} + \underbrace{\overline{\pi}(1-\zeta)}_{\text{High-skilled workers}} + \underbrace{\overline{\pi}\zeta}_{\text{Teachers}} . \tag{3.2.1}$$

The life time utility is defined over a non-storable consumption good using the log utility function:

$$U_t = lnc_{t+1} \tag{3.2.2}$$

We abstract from modeling the consumption in the childhood and the young adulthood for simplicity. In period 0, individuals only engage in learning activities. In period 1, individuals work and save. In period 2, individuals retire and consume savings from period 1. This simplification has been adopted in the literature such as Galor and Zeria (1993). In a full-blown two-period overlapping generations model with log utility, the optimal consumption and saving are both constant fractions of the total income. Therefore, it does not change the economic intuition by assuming that agents only consume in the second period. In addition, as revealed in the following section, teachers' expected utility maximization problem becomes less complicated with this assumption.

Goods are produced using three inputs: physical capital K_t, aggregate effective low-skilled labor $\underline{H_t}$, and aggregate effective high-skilled labor $\overline{H_t}$ according to a nested-CES production function:

$$Y_t = A[K_t^\theta + \phi(\underline{H_t})^\theta]^{\frac{\alpha_1}{\theta}}(\overline{H_t})^{\alpha_2}, \tag{3.2.3}$$

where A is the total factor productivity. $\alpha_1 + \alpha_2 \equiv 1$, and $\theta \in (-\infty, 1]$. Low-skilled workers and physical capital are substitutes, and their combination is complementary with the high-skilled labor. The high-skilled labor force consists of high-skilled workers and the absent teachers working on side jobs outside schools. Everyone has one unit of working time. If a teacher spends m_t amount of his time to work in the informal sector, then $(1-m_t)$ is the amount of time dedicated to teaching activities. The total supply of effective low-skilled and high-skilled labor force can be expressed as follows:

$$\begin{aligned} \underline{H_t} &= \underline{\pi}\underline{h_t}, \\ \overline{H_t} &= (1-\zeta+\zeta m_t)\overline{\pi}\overline{h_t} \end{aligned} \tag{3.2.4}$$

where $\underline{h_t}$ and $\overline{h_t}$ are the per capita human capital of high-skilled and low-skilled individuals respectively.

There are two stages of human capital production. The first is lower education taking place in primary and secondary schools. The second one is higher education in vocational schools and universities. The low human capital $\underline{h}$ is generated according to a Cobb-Douglas technology:

$$\underbrace{\underline{h_{t+1}}}_{\text{Low human capital}} = B_1[\underbrace{\overline{\pi}\zeta(1-m_t)\overline{h_t}}_{\text{Teachers' efforts}}]^{\gamma_1}(\underbrace{\overline{\pi}\overline{h_t}+\underline{\pi}\underline{h_t}}_{\text{Parent generation's human capital}})^{\gamma_2}, \tag{3.2.5}$$

where $\gamma_1 + \gamma_2 \equiv 1$. B_1 is the total factor productivity in low human capital production. The quality of low human capital depends on teachers' contribution and parent generation's human capital. m_t is a teacher's absent time from teaching obligations and $(1-m_t)\overline{h_t}$ is a teacher's effective contribution to his teaching duty. Among all adults with high human capital, a fraction ζ become school teachers, thus $\overline{\pi}\zeta$ is the total number of teachers in this economy. Teachers' contribution to basic education is $\overline{\pi}\zeta(1-m_t)\overline{h_t}$. Since $\overline{\pi}$ and $\underline{\pi}$ denote shares of individuals in each generation with high and low human capital, the weighted average human capital in the parent generation is $\overline{\pi}\overline{h_t}+\underline{\pi}\underline{h_t}$.

We abstract from modeling teachers in higher education, and assume that higher education outcome depends solely on government funding and the lower education quality according to a Cobb-Douglas production function:

$$\underbrace{\overline{h_{t+1}}}_{\text{High human capital}} = B_2(\underbrace{e_tY_t}_{\text{Gov funding}})^{\eta_1}(\underbrace{\underline{h_{t+1}}}_{\text{Low human capital}})^{\eta_2}, \tag{3.2.6}$$

where B_2 is the total factor productivity in the high human capital production, $\eta_1+\eta_2 \equiv 1$. e_t is the share of GDP spent on higher education funding.

3.2.1 Teachers' Problem

In this section, we set up the teachers' problem and solve for their optimal absent time. The World Bank's survey team found a wide array of reasons for teachers' absenteeism. First, low wages paid to non-regular teachers raises opportunity cost and pecuniary incentive to seek income sources outside schools. Second, even though regular faculty members are better paid than non-regular ones, they receive weak supervision and enjoy a high level of job security. The low risk of being dismissed induces excessive absenteeism (Kremer, et al. 2005). Third, the monitoring and sanctions against absenteeism tend to be weak or non-exist due to insufficient visits of education officials and parental involvement in schooling (Chaudhury, et al. 2004). Therefore we model the teachers' problem as follows. Primary and secondary school teachers at time t receive a *contract wage*, $\tilde{w}_t$, indexed to the high-skilled workers' wage: $\tilde{w}_t = \kappa \overline{w_t}$, where $\kappa > 0$. If a teacher fails to fulfill his teaching obligation and uses his absent time to work in a side job, there is a possibility of getting caught and punished. Assume the financial penalty depends on the absent length and the punishment level. Denote m_t to be the absent time and ρ to be the harshness level of punishment. Therefore, if a teacher is charged with absenteeism in school, the penalty due is $\rho m_t \tilde{w}_t \overline{h_t}$ and his total income before tax is:

$$(1 - \rho m_t)\tilde{w}_t \overline{h_t} + \overline{w_t}\overline{h_t} m_t, \tag{3.2.7}$$

On the other hand, if the absenteeism is not discovered and sanctioned, the teacher's total income before tax is

$$\tilde{w}_t \overline{h_t} + \overline{w_t}\overline{h_t} m_t. \tag{3.2.8}$$

The longer teachers are absent in schools, the higher is the risk of getting caught. Assume the probability of an absent teacher getting caught is an increasing function of his absent time, m:

$$p(m) = m^{\psi}, \qquad \psi > 0 \tag{3.2.9}$$

Since $m \in [0, 1]$, the function $p(m)$ has values between 0 and 1 whenever ψ is positive.

3.2.2 The Government

The government taxes all official labor income at a flat rate τ. Teacher income from side jobs in the informal sector is not taxed because it is difficult to precisely detect the location and income level from those jobs. The government pay for primary and secondary school teachers and funds higher education with the tax revenue and penalty charges. The government budget constraint is given by

$$\begin{aligned}&\tau[\underline{w_t h_t \pi} + \overline{w_t}\overline{h_t}\overline{\pi}(1-\zeta) + \tilde{w}_t\overline{h_t}\overline{\pi}\zeta] + p(m_t)\rho m_t \tilde{w}_t\overline{h_t}\overline{\pi}\zeta \\ &= e_t Y_t + \tilde{w}_t\overline{h_t}\overline{\pi}\zeta + \triangle_g Y_t,\end{aligned} \tag{3.2.10}$$

where $\tau[\underline{w_t h_t \pi} + \overline{w_t}\overline{h_t}\overline{\pi}(1-\zeta) + \tilde{w}_t\overline{h_t}\overline{\pi}\zeta]$ is the total tax revenue; $p(m_t)\rho m_t \tilde{w}_t\overline{h_t}\overline{\pi}\zeta$ is the expected value of financial penalty on absent teachers; e_t is the proportion of government funding for higher education; the total amount of wage paid to teachers is $\tilde{w}_t\overline{h_t}\overline{\pi}\zeta$; $\triangle_g$ is the fraction of government surplus ($\triangle_g > 0$) or government deficit ($\triangle_g < 0$). Notice that, it is the teachers' pre-punishment income $\tilde{w}_t\overline{h_t}$ that is taxed, meaning the financial charge on teacher absenteeism is not tax deductable.

3.3 Solving the Model

3.3.1 Solving Households' Problem for Non-Teachers

Low-skilled workers solve the following problem:

$$\begin{aligned}\max_{\{\underline{c_t},\underline{c_{t+1}},\underline{s_t}\}} \quad & ln\underline{c_{t+1}} \\ s.t. \quad & \underline{c_t} + \underline{s_t} = (1-\tau)\underline{w_t h_t} \\ & \underline{c_{t+1}} = (1+r_{t+1})\underline{s_t}\end{aligned} \tag{3.3.1}$$

where $\underline{c}$ and $\underline{s}$ refer to the consumption and saving of low-skilled workers. The solution of saving for low-skilled workers is:

$$\underline{s_t} = (1-\tau)\underline{w_t h_t} \tag{3.3.2}$$

High-skilled workers solve the following problem:

$$\begin{aligned} \max_{\{\overline{c_t},\overline{c_{t+1}},\overline{s_t}\}} \quad & ln\overline{c_{t+1}} \\ s.t. \quad & \overline{c_t}+\overline{s_t}=(1-\tau)\overline{w_t}\overline{h_t} \\ & \overline{c_{t+1}}=(1+r_{t+1})\overline{s_t} \end{aligned} \tag{3.3.3}$$

where $\bar{c}$ and $\bar{s}$ refer to the consumption and saving of high-skilled workers. The solution of saving for high-skilled workers is:

$$\overline{s_t}=(1-\tau)\overline{w_t}\overline{h_t} \tag{3.3.4}$$

3.3.2 Solving Households' Problem for School Teachers

The teachers' problem is less straightforward due to the uncertainty of the financial penalty. The teachers' problem can be written as follows:

$$\begin{aligned} \max_{\{\hat{c_t},\hat{c_{t+1}},\hat{s_t},m_t\}} \quad & E[ln\hat{c_{t+1}}] \\ s.t. \quad & \hat{c_t}+\hat{s_t}=\text{Income}(m_t) \\ & \hat{c_{t+1}}=(1+r_{t+1})\hat{s_t} \end{aligned} \tag{3.3.5}$$

Where $i=1,2$ refer to two cases: whether the absenteeism gets caught or not. $\hat{c}$ and $\hat{s}$ refer to the consumption and saving of teachers.

$$\text{Income}(m_t)=\begin{cases} (1-\tau)\kappa\overline{w}_t\overline{h}_t+(1-\rho\kappa)m_t\overline{w}_t\overline{h}_t, & i=1 \\ (1-\tau)\kappa\overline{w}_t\overline{h}_t+m_t\overline{w}_t\overline{h}_t, & i=2 \end{cases}$$

The teachers' problem equation (3.3.5) can be written as:

$$\begin{aligned} \max_{\{m_t\}} \quad & m_t^{\psi}ln[(1-\tau)\kappa\overline{w}_t\overline{h}_t+(1-\rho\kappa)m_t\overline{w}_t\overline{h}_t] \\ & +(1-m_t^{\psi})ln[(1-\tau)\kappa\overline{w}_t\overline{h}_t+m_t\overline{w}_t\overline{h}_t] \end{aligned} \tag{3.3.6}$$

We solve for teachers' optimal absent time m_t from the first order condition:

$$\begin{aligned} & \overbrace{-\psi m_t^{\psi-1}ln[(1-\tau)\kappa+(1-\rho\kappa)m_t]+\psi m_t^{\psi-1}ln[(1-\tau)\kappa+m_t]}^{\text{(1) Marginal Cost}} \\ & =\underbrace{m^{\psi}\frac{1-\rho\kappa}{(1-\tau)\kappa+(1-\rho\kappa)m_t}}_{\text{(2) MC or MB}}+\underbrace{(1-m_t^{\psi})\frac{1}{(1-\tau)\kappa+m_t}}_{\text{(3) Marginal Benefit}} \end{aligned} \tag{3.3.7}$$

The second order condition is given by

$$\begin{aligned}&\psi(\psi-1)m_t^{\psi-2}ln\frac{(1-\tau)\kappa+(1-\rho\kappa)m_t}{(1-\tau)\kappa+m_t}\\&+2\psi m_t^{\psi-1}[\frac{1-\rho\kappa}{(1-\tau)\kappa+(1-\rho\kappa)m_t}-\frac{1}{(1-\tau)\kappa+m_t}]\\&-m_t^{\psi}\frac{(1-\rho\kappa)^2}{(1-\tau)\kappa+(1-\rho\kappa)m_t}-(1-m_t^{\psi})\frac{1}{(1-\tau)\kappa+m_t}\end{aligned}\tag{3.3.8}$$

A sufficient condition for expression (3.3.8) to be negative is

$$\psi \geq 1 \tag{3.3.9}$$

Let m_t^* denote the solution to equation (3.3.7). Since we made the simplification in the model that the young save all their income and only consume in the second period, teachers' saving can be expressed as:

$$\hat{s}_t = [(1-\tau)\kappa + m_t^* - \rho {m_t^*}^{\psi+1}\kappa]\overline{w_t}\overline{h_t} \tag{3.3.10}$$

Equation (3.3.7) is decomposed into three blocks in order to analyze the marginal cost and marginal benefit of teachers' absent time. Block (1) is one term of the marginal cost, representing marginal change in probabilities of absenteeism being caught. Block (3) is one term of the marginal benefit, representing extra utility from informal sector when absenteeism is not caught. Different from blocks (1) and (3), block (2) can be either marginal cost or marginal benefit depending on parameter values, representing marginal change in utility from extra income from informal sector. If the economy is in a regime with weak punishment and low teacher wage, so that $\rho\kappa < 1$, then block (2) is one term of marginal benefit. On the other hand, if the economy has strong punishment, or high teacher wage, or both, so that $\rho\kappa > 1$ and is essentially a marginal cost. What is the economic intuition? Given the labor tax rate τ, the punishment level ρ and the teacher wage κ, school teachers choose their optimal amount of absent time. The length of absence needs to provide teachers a combination of the lowest probability of being caught and highest income from the informal jobs. However, there is a trade-off: while a longer absence increases informal job income, it also raises the odds of being caught and incurs a higher financial penalty. Moreover, the trade-off varies depending on parameter values and policy regimes. Figure 14 shows this relationship. If the absent time is zero, a teacher's income is given by $(1-\tau)\kappa\overline{w}\overline{h}$, which we define as the "baseline income". If a teacher is absent ($m > 0$) but is not caught, his total income will be $(1-\tau)\tilde{w}_t\overline{h}_t + m_t\overline{w}_t\overline{h}_t$, higher than the baseline income and is shown as the line with largest slope in Figure 14. If the absenteeism is discovered and punished, then the teacher will receive a relatively lower income, $(1-\tau)\tilde{w}_t\overline{h}_t + m_t\overline{w}_t\overline{h}_t - \rho m_t\tilde{w}_t\overline{h}_t$. If $\rho\kappa < 1$, then the income is on the line with the second largest slope. And if $\rho\kappa > 1$, then the income is on the line with negative slope. The expected income when absent time is m is a linear probabilistic combination of the income when the absenteeism is not caught (the solid line) and the income when the absenteeism is caught (either of the dashed lines). In an economy with $\rho\kappa < 1$, absent teachers always guarantee a higher income than those who never skip teaching, since the two possible incomes are both above the baseline. On the contrary, when $\rho\kappa > 1$, teachers face the risk of suffering an income level lower than the baseline.

3.3.3 Solving Firm's Problem

Competitive firms choose optimal levels of physical capital, high-skilled and low-skilled labor to maximize profit given market prices:

$$\max_{\{K_t,\overline{H_t},\underline{H_t}\}} \quad F(K_t,\overline{H_t},\underline{H_t}) - \overline{w_t}\overline{H_t} - \underline{w_t}\underline{H_t} - q_tK_t \qquad \text{given}\{\overline{w_t},\underline{w_t},q_t\}. \tag{3.3.11}$$

Knowing the factor prices $\{\overline{w_t},\underline{w_t},q_t\}$, a competitive firm's demand for low-skilled, high-skilled labor and physical capital are solved from the following three equations:

$$\begin{aligned}
\overline{w_t} &= \alpha_2\frac{Y_t}{\overline{H_t}}, \\
\underline{w_t} &= \alpha_1\frac{Y_t}{\underline{H_t}}\frac{\phi\underline{H_t}^{\theta}}{K_t^{\theta}+\phi\underline{H_t}^{\theta}}, \\
q_t = 1 + r_t &= \alpha_1\frac{Y_t}{K_t}\frac{K_t^{\theta}}{K_t^{\theta}+\phi\underline{H_t}^{\theta}}
\end{aligned} \tag{3.3.12}$$

3.4 Competitive Equilibrium

Given government policies on labor tax rates, teacher wages, and punishment for teacher absenteeism, $\{\rho_t, \tau_t, \kappa_t\}_{t=0}^{\infty}$, a competitive equilibrium is a collection of sequences of decisions of low-skilled workers $\{\underline{c_t}, \underline{s_t}, \underline{c_{t+1}}\}_{t=0}^{\infty}$, sequences of decisions of high-skilled workers $\{\overline{c_t}, \overline{s_t}, \overline{c_{t+1}}\}_{t=0}^{\infty}$, sequences of decisions of teachers $\{\hat{c_t}, \hat{s_t}, \hat{c_{t+1}}\}_{t=0}^{\infty}$, sequences of aggregate physical capital, low and high human capital $\{K_t, \underline{H_t}, \overline{H_t}\}_{t=0}^{\infty}$, and sequences of prices $\{\underline{w_t}, \overline{w_t}, q_t\}_{t=0}^{\infty}$ satisfying the following criteria:

1. Given the *prices*, the sequences $\{\underline{c_t}, \underline{s_t}, \underline{c_{t+1}}, \overline{c_t}, \overline{s_t}, \overline{c_{t+1}}, \hat{c_t}, \hat{s_t}, \hat{c_{t+1}}, m_t\}_{t=0}^{\infty}$ solve the households' problems;

2. Given the *prices*, the sequences $\{K_t, \overline{H_t}, \underline{H_t}\}_{t=0}^{\infty}$ solve the firm's problem;

3. The commodity market clears

$$(\overline{c_t} + \overline{s_t})\overline{\pi}(1-\zeta) + (\hat{c_t} + \hat{s_t})\overline{\pi}\zeta + (\underline{c_t} + \underline{s_t})\underline{\pi} + (e_t + \triangle_g)Y_t = Y_t; \tag{3.4.1}$$

4. The physical capital and labor markets both clear

$$\begin{aligned} K_{t+1} &= \underline{s_t}\underline{\pi} + \overline{s_t}\overline{\pi}(1-\zeta) + \hat{s_t}\overline{\pi}\zeta, \\ \overline{H_t} &= (1-\zeta+\zeta m_t)\overline{\pi}\overline{h_t}, \\ \underline{H_t} &= \underline{\pi}\underline{h_t}; \end{aligned} \tag{3.4.2}$$

5. The government budget constraint equation(3.2.10) holds.

3.5 The Balanced Growth Paths

A balanced growth equilibrium is a collection of sequences $\{K_t, \underline{H_t}, \overline{H_t}\}_{t=0}^{\infty}$, which satisfies the definition of a competitive equilibrium and grows at the same constant rate. In order to find the balanced growth paths, we show the law of motion for the low and high human capital and the physical capital as follows:

$$\underline{H_{t+1}} = \underbrace{B_1\underline{\pi}[\frac{(1-m_t)\zeta}{1-\zeta+\zeta m}]^{\gamma_1}}_{D_0} \overline{H_t}^{\gamma_1}(\underline{H_t} + \frac{\overline{H_t}}{1-\zeta+\zeta m})^{\gamma_2} \tag{3.5.1}$$

$$\overline{H_{t+1}} = \underbrace{B_2\overline{\pi}(1-\zeta+\zeta m)\underline{\pi}^{-\eta_2}}_{D_1} e_t^{\eta_1} Y_t^{\eta_1} \underline{H_{t+1}}^{\eta_2} \tag{3.5.2}$$

$$K_{t+1} = \{\alpha_1(1-\tau)\frac{\phi \underline{H_t}^{\theta}}{K_t^{\theta}+\phi\underline{H_t}^{\theta}} + \underbrace{\frac{\alpha_2(1-\tau)(1-\zeta)}{1-\zeta+\zeta m_t} + \frac{\alpha_2[(1-\tau)\kappa + m_t - \rho m_t^{\psi+1}\kappa]\zeta}{1-\zeta+\zeta m_t}}_{D_2}\}Y_t \tag{3.5.3}$$

We can simplify the mathematical expressions by denoting D_0, D_1, D_2 as follows:

$$D_0 = B_1\underline{\pi}[\frac{(1-m_t)\zeta}{1-\zeta+\zeta m}]^{\gamma_1};$$

$$D_1 = B_2\overline{\pi}(1-\zeta+\zeta m)\underline{\pi}^{-\eta_2};$$

$$D_2 = \frac{\alpha_2(1-\tau)(1-\zeta)}{1-\zeta+\zeta m_t} + \frac{\alpha_2[(1-\tau)\kappa + m_t - \rho m_t^{\psi+1}\kappa]\zeta}{1-\zeta+\zeta m_t}.$$

Dividing the expression for K_{t+1} by the one for $\overline{H_{t+1}}$ yields:

$$\begin{aligned} &K_{t+1}/\overline{H_{t+1}} \\ &= \frac{A^{\eta_2}[\alpha_1\frac{\phi(\underline{H_t}/\overline{H_t})^{\theta}}{(K_t/\overline{H_t})^{\theta}+\phi(\underline{H_t}/\overline{H_t})^{\theta}} + D_2][(K_t/\overline{H_t})^{\theta}+\phi(\underline{H_t}/\overline{H_t})^{\theta}]^{\alpha_1\eta_2/\theta}}{D_0^{\eta_2}D_1 e^{\eta_1}[\underline{H_t}/\overline{H_t} + 1/(1-\zeta+\zeta m)]^{\gamma_2\eta_2}}. \end{aligned} \tag{3.5.4}$$

Dividing the expression for $\underline{H_{t+1}}$ by the one for $\overline{H_{t+1}}$ yields:

$$\underline{H_{t+1}}/\overline{H_{t+1}} = \frac{D_0^{\eta_1}}{A^{\eta_1}D_1}\frac{[(\underline{H_t}/\overline{H_t}) + 1/(1-\zeta+\zeta m)]^{\gamma_2\eta_1}}{e_t^{\eta_1}[(K_t/\overline{H_t})^{\theta}+\phi(\underline{H_t}/\overline{H_t})^{\theta}]^{\frac{\alpha_1\eta_1}{\theta}}}. \tag{3.5.5}$$

Modification of the government budget constraint yields:

$$\begin{aligned} &\tau[\alpha_1\frac{\phi(\underline{H_t}/\overline{H_t})^{\theta}}{(K_t/\overline{H_t})^{\theta}+\phi(\underline{H_t}/\overline{H_t})^{\theta}} + \alpha_2\frac{1-\zeta}{1-\zeta+\zeta m}] + \frac{\alpha_2(\tau-1+\rho m_t^{\psi+1})\kappa\zeta}{1-\zeta+\zeta m_t} \\ &= e_t + \triangle_g. \end{aligned} \tag{3.5.6}$$

If we name the ratios between the physical capital and high human capital x_t, and that between the low human capital and high human capital y_t:

$$K_t/\overline{H_t} = x_t \tag{3.5.7}$$

$$\underline{H_t}/\overline{H_t} = y_t, \tag{3.5.8}$$

then we can rewrite equation(3.5.4), equation(3.5.5) and equation(3.5.6) in a more concise way:

$$
\begin{cases}
x_{t+1} = \frac{A^{\eta_2}}{D_0^{\eta_2} D_1} \frac{(\alpha_1 \frac{\phi y_t^\theta}{x_t^\theta + \phi y_t^\theta} + D_2)(x_t^\theta + \phi y_t^\theta)^{\alpha_1 \eta_2/\theta}}{e_t^{\eta_1} (y_t + 1/(1-\zeta+\zeta m_t))^{\gamma_2 \eta_2}} \\
y_{t+1} = \frac{D_0^{\eta_1}}{A^{\eta_1} D_1} \frac{(y_t + 1/(1-\zeta+\zeta m_t))^{\gamma_2 \eta_1}}{e_t^{\eta_1} (x_t^\theta + \phi y_t^\theta)^{\alpha_1 \eta_1/\theta}} \\
\tau[\alpha_1 \frac{\phi y_t^\theta}{x_t^\theta + \phi y_t^\theta} + \alpha_2 \frac{1-\zeta}{1-\zeta+\zeta m_t}] + \frac{\alpha_2(\tau - 1 + \rho m_t^{\psi+1})\kappa\zeta}{1-\zeta+\zeta m_t} = e_t + \triangle_g
\end{cases}
$$

The growth rates of the high and low human capital and physical capital are expressed as follows:

$$
\begin{aligned}
g_{\underline{H}} &= D_0 y_t^{-\gamma_1} [1 + \frac{1}{y_t(1-\zeta+\zeta m_t)}]^{\gamma_2} \\
g_{\overline{H}} &= D_1 e_t^{\eta_1} [A(x_t^\theta + \phi y_t^\theta)^{\frac{\alpha_1}{\theta}}]^{\eta_1} (g_{\underline{H}} y_t)^{\eta_2} \\
g_K &= [\alpha_1(1-\tau)\phi y_t^\theta / (x_t^\theta + \phi y_t^\theta) + D_2] A (1 + \phi(y_t/x_t)^\theta)^{\alpha_1/\theta} x_t^{-\alpha_2}
\end{aligned}
\tag{3.5.9}
$$

3.6 Policy Experiments Under Different Policy Regimes

We are interested in how policy reforms affect teacher absenteeism, economic growth, government funding for higher education, the ratios between physical and human capital, and between the low and high human capital. The policy instruments include taxes, teachers' wage index, and the punishment for teachers' absence. We cannot pick one policy instrument alone while ignoring the various interactions among all others. For example, in order to investigate the influences of changing teachers' wage index on balanced growth paths, we need to take into account whether the tax rate is high/medium/low, and whether punishment for teachers' absence is strong or weak. Therefore, we focus on one policy instrument at one time, under several regimes that are combinations of the other two policy variables. For instance, we consider how increasing teachers' wage index affects growth rates under four regimes: high tax and high punishment, high tax and low punishment, low tax and high punishment, and lastly low tax and low punishment.

The chosen parameter values are presented in the appendix. The values of total factor productivity, A, B_1, B_2, are set at 5, 10 and 10 respectively. The income share of physical capital and low-skilled labor, α_1 is chosen to be 0.65, and that of high-skilled labor is 0.35. Following Su (2004), the share of teachers' contribution in low human capital production γ_1 is chosen to be 0.5. In the high human capital production function, the share of government funding's contribution η_1 is chosen to be 0.5. Following Azam (2007), the proportion of total population with low human capital is 70%. The other 30% of the population have high human capital, and this group include both high-skilled workers and school teachers. The fraction of school teachers in the group with high human capital, ζ, is set to be 5%.

In the following subsections, we seek policy implications of three experiments: raising the labor tax rate from 0.15 to 0.6, pushing the punishment level for teacher absenteeism from 0.7 to 1.5, and increasing teacher wage index from 0.8 to 1.5. In each experiment, we show adjustments on both balanced growth paths (the long-run) and transition paths (the short-run).

3.6.1 Raising Labor Taxes

3.6.1.1 Balanced Growth Paths

Government revenue depends on both labor tax rates and the tax base. If the tax rate rises while the tax base remians fairly stable, government revenue increases. On the contrary, if people respond to a tax increase by cutting labor supply severely, government revenue decreases. In this paper, skilled and unskilled workers both have inelastic labor supply, so a tax hike has no effect on their respective labor supply. However, teachers may work on side jobs in the informal sector outside schools. Since the informal sector is neither taxed nor monitored by the government, a tax increase can potentially induce more teacher absenteeism. The adjustments in teachers' absent time in response to a tax hike are conditional on policy regimes of teacher wages and the penalty on absenteeism. In this paper, we experiment by raising the labor tax rate τ from 15% to 60%, under each of the following four policy regimes:

(1) Low teacher wages ($\kappa = 0.8$) and Weak punishment ($\rho = 0.6$).

(2) High teacher wages ($\kappa = 1.5$) and Weak punishment ($\rho = 0.6$);

(3) Low teacher wages ($\kappa = 0.8$) and Strong punishment ($\rho = 1.4$);

(4) High teacher wages ($\kappa = 1.5$) and Strong punishment ($\rho = 1.4$);

The numerical results are summarized in Table 17. When the labor tax rate increases, teachers absenteeism increases only when the punishment is weak and teachers are underpaid. The absenteeism declines in the other three regimes. This seems to be a little puzzling at first: when the labor tax rate rises, teachers have lower disposable income so that they will need to compensate the loss by working more in informal jobs. If such speculation were correct, then teacher absenteeism would increase in response to the tax hike. However, this logic fails to explain the whole story. Teachers choose the length of absent time taking into account the marginal benefit and marginal cost of one unit of absent time. Whether teacher absenteeism rises or falls depends on how the tax hike impacts both the marginal benefit and marginal cost of absenteeism. In equation (3.3.7), the labor tax rate τ appears in both the marginal cost and marginal benefit terms. Ceteris paribus, if τ increases, the marginal cost and marginal benefit of teachers' absent time both increase. The marginal cost is the financial penalty on absenteeism and the marginal benefit derives from the informal sector income. In Figure 15, dashed lines represent marginal benefits and solid lines stand for marginal costs. A higher labor tax rate increases both marginal costs and marginal benefits in all four regimes. The net effect of the tax increase on teacher absenteeism depends on the changes in marginal benefits relative to those in marginal costs. If the increment in marginal costs exceed that in marginal benefits, teachers scale back their absenteeism, and vice versa. Figure 15 demonstrates that in the first regime with low wage and low punishment (the upper left one), the marginal costs (solid lines) have a relatively smaller adjustment compared with the marginal benefits (the dashed lines), hence the optimal absent time increases. In other three regimes, the changes in marginal costs exceed those in marginal benefits, which results in cutbacks in absenteeism. In other words, if an economy has weak punishment (low ρ) and poorly paid teachers (low κ), then teachers will scale up absenteeism when the labor tax rate rises. In *other* cases, teachers will reduce their absent time in response to the tax hike.

How do balanced growth paths adjust if the labor tax rate rises? The left panel in Figure 16 shows that, when the labor tax rate increases from 15% to 60%, in the regime with weak punishment and low teacher wage, teacher absenteeism rises from 0.81 to 0.82; in the regime of strong punishment and high teacher wage, teacher absenteeism declines from 0.28 to 0.24; in the regime of weak punishment and low teacher wage, absenteeism falls from 0.43 to 0.40; in the regime of strong punishment and high teacher wage, teacher absenteeism decreases from 0.49 to 0.46. These results illustrate that, if teachers are underpaid and ineffectively supervised, then teacher absenteeism is not only severe, but also rather insensitive to changes in the tax rate. On the contrary, if teachers are well paid in a system with convincingly high penalties, then absenteeism is low. Furthermore, the tax increase has a more significant influence in cutting teacher absenteeism in such cases—as the labor tax rate rises from 15% to 60%, teacher absenteeism declines from 28% to 24%, a 14% drop.

Facing high teacher wage (κ) and strong punishment on discovered absence (ρ), teachers weigh the benefit from informal jobs and the cost of being caught. In Figure 14, the baseline income with no absence is $(1-\tau)\kappa\overline{w}\overline{h}$. There are two cases regarding the effects of policies on teacher wages and penalties on absenteeism. First, if $\rho\kappa > 1$, an absent teacher may have income higher or lower than the baseline depending on whether the absence is caught or not. Second, if $\rho\kappa < 1$, an absent teacher will have a guaranteed higher income compared with the baseline. If the economy is in the first case, teachers will consider the potential risk involved in getting a permanently lower income, the possibility of which induces teachers to scale back absenteeism. Moreover, the rising labor tax rate decreases teacher incomes in all scenarios. Teachers with lower income are more risk averse and more likely to cut back their absenteeism in order to stay safe.

In the right panel in Figure 16, economic growth rates increase in all four regimes when the labor tax rate increases. The regime with strong punishment and high teacher wage has the largest increase: its growth rate increases from 1.24 to 2.35, a 84% improvement. In the regime with weak punishment and low teacher wage, the growth rate increases from 0.92 to 1.49, a 57% improvement. There are several reasons for high economic growth accompanying the rising tax rate. First, the tax increase directly boosts the higher education funding and improves high human capital accumulation. Second, when tax rate increases, the absenteeism either decreases a lot or increases only moderately. The declining teacher absenteeism will improve the quality of basic education and the accumulation of low human capital. Furthermore, the progress made in basic education also benefits the higher education outcomes, as students are academically better prepared. The two effects reinforce each other and generate in high economic growth.

3.6.1.2 Transition Paths

The previous subsection studies teacher absenteeism and economic growth rate on the balanced growth path with an increasing labor tax rate. Every point in Figure 16 is on balanced growth paths. While this analysis is important for the long-run, it is equally crucial to study the short-run, which reveals the economic transition from one balanced growth path to another. Thus, this subsection focuses on performances of economic variables—teacher absenteeism, GDP growth rates, physical capital and human capital growth rates—on the transition paths.

Figures 17 and 18 describe transition paths following a tax hike from 15% to 60% in period 1. It takes about 5 periods for the economy to transit from the old balanced growth path to the new one. When the tax rate rises, the GDP growth rate drops for one period followed by a permanently higher rate. When we are in the regime of strong punishment and high teacher wage, the GDP growth rate decreases from 1.92 to 0.98 in the period with the policy change, but then converges to 2.82. The higher education funding increases following the tax hike, from 0.78% to 4.2% in the period following the tax rate change, and converges to 5.12%. Generous higher education funding promotes the high human capital production in period 1, and people who benefit from it start to work either as high-skilled workers or as school teachers. Better basic education accelerates the low human capital accumulation from period 2 onward. When the labor tax rate rises, people's disposable income and savings both decrease, which cause the decline in capital stock. This also explains why the growth rate of physical capital drops following the tax hike. After the tax policy change, the growth rates of low human capital, high human capital and physical capital all start recovery, and thus the GDP growth rate comes back and converges to a higher rate on the new balanced growth path.

We are also interested in fluctuations in the GDP level following the policy reform. Figure 19 provides a comparison of GDP levels with or without the tax hike. Regardless of regimes, the GDP levels (dashed lines) fall short of what would have been without the policy reform (solid lines), but catch up after several periods. The length of the catching-up varies across different regimes: In the regime with weak punishment and low wage, it takes about 3 periods. And in the regime with strong punishment and high wage, it takes about 2 periods.

What contributes to the temporary GDP decrease? In order to identify the dominant factor, we decompose production (Y) into levels of physical capital (K), low-skilled labor ($\underline{H}$), and high-skilled labor ($\overline{H}$). Figure 20 displays changes in the regime with weak punishment and low wage. The physical capital accumulation stumbles due to shrinking disposable income and savings under the higher tax rate. The low-skilled labor $\underline{H}$ under the high tax rate keeps up and soon exceeds that under the low tax rate. The high-skilled labor $\overline{H}$ under the high tax rate always outperforms that under the low tax rate. This is because, teacher absenteeism increases (even though only slightly) in response to the tax hike in the current regime, and thus the high-skilled labor supply increases by 0.06% at t=1 (a quantity effect). In addition, the higher education quality improves thanks to the boosted government funding, which leads to an improved per-capita high human capital (a quality effect). The quantity and quality effects together result in an enlarging high-skilled labor force. Lastly, the compounding effect of changes in physical and human capital is that GDP decreases in the short run but gains strength in the long run.

Figure 21 displays changes in the regime with strong punishment and high wage. Similar with figure 20, the physical capital accumulation under high tax rate falls short of that under low tax rate. Different with Figure 20, the high-skilled labor supply ($\overline{H}$) also decreases temporarily when the tax rate rises. This is because, in the current regime, teachers scale back their absenteeism when the tax rate shoots up, and thus decrease the high-skilled labor force ($\overline{H}$). Because the proportion of teachers in those with high human capital is only 5%, the negative impact of decreasing teacher absenteeism on the high-skilled labor force is small. As our numerical experiment suggests, the temporary drop in the high-skilled labor force at t=1 due to the cutback of teacher absenteeism is only about 0.21%. Lastly, when we consider changes in physical and human capital together, we find that GDP experiences a short-run loss before catching up in period 3.

3.6.2 Improving Teacher Wages

3.6.2.1 Balanced Growth Paths

Our second policy experiment is to increase the teacher wage index. Unsatisfactory income for school teachers has been recognized as one of the important factors affecting teacher absenteeism. In the World Bank survey, one question asked school teachers to "Rank the three most important problems you face". 14.90% responded "Inadequate salaries", the second most frequently chosen answer. In this paper, we assume that school teachers receive a contract wage which is indexed to the high-skilled worker wage. This index is chosen by policy makers, and it can be either higher or lower than one so that teachers may make more or less than high-skilled workers. For the main purpose of this paper, we do not consider the specific reasons for choosing teaching as one's career. We admit that those reasons are both important and complicated in reality. There can be monetary reasons as well as personal interests that attract a young person to enter the teaching profession.

We examine changes in economic variables on balanced growth paths when the teacher wage index is raised from 0.8 to 1.5. The influences of this policy instrument are conditional on policy regimes of taxes and financial penalties on absenteeism. Thus, we will show adjustments of teacher absent time, economic growth rates, physical and human capital accumulations in the following four regimes:

(1) Low Tax ($\tau = 0.15$) and Weak Punishment ($\rho = 0.7$);

(2) Low Tax ($\tau = 0.15$) and Strong Punishment ($\rho = 1.4$);

(3) High Tax ($\tau = 0.6$) and Weak Punishment ($\rho = 0.7$);

(4) High Tax ($\tau = 0.6$) and Strong Punishment ($\rho = 1.4$).

Figure 22 displays the balanced growth paths for teacher absenteeism and GDP growth rates when the teacher wage index is raised from 0.8 to 1.5. Since the government budget is always balanced, the financing of raising teacher wage is at the cost of downsizing other government expenditure. Table 18 records the numerical results. In all four policy regimes, teachers scale down their absent time significantly if they are paid better; hence, it justifies that inadequate salaries for school teachers is a leading factor for absenteeism. Nevertheless, the wage increase affects teacher absenteeism to various degrees conditional upon policy regimes. The left panel in Figure 22 shows that, in the regime with low tax and strong punishment, the absent time decreases from 0.44 to 0.28; in the regime with high tax and strong punishment, the absent time decreases from 0.40 to 0.24. Moreover, this policy instrument is more effective in fighting absenteeism in economies with weak punishment. In the regime with low tax and weak punishment, teachers' absent time decreases from 0.81 to 0.49; in the regime with high tax and weak punishment, the absent time decreases from 0.82 to 0.46; Teachers seek other employment opportunities as long as they are underpaid. Even if the punishment is strong, teachers will still take the risk since they have very little to lose. Our experiment demonstrates that raising the teacher wage index is capable of curbing absenteeism by 30-40% regardless of policies on taxes and penalties.

The right panel in Figure 22 illustrates that, GDP growth rates increase in most regimes when the teacher wage index rises. In economies experiencing an adequate reduction in teacher absenteeism, the GDP growth rates increase the fastest. For example, in the regime with low tax and weak punishment, the GDP growth rate increases from 0.93 to 1.13, a 22% progress. The scaling down in teacher absenteeism improves the quality of lower education, which benefits both the low and high human capital accumulations in the long-run and hence promotes economic growth.

3.6.2.2 Transition Paths

In this section, we examine changes in economic variables on transition paths when the teacher wage index is raised from 0.8 to 1.5. Figure 23 displays that teachers cut down their absent time regardless of the policy regimes on taxes and punishments. The GDP growth rate increases in most regimes. The higher education funding remains at roughly the same level in all regimes.

If we break down GDP growth rate into the growth rates of low human capital, high human capital and physical capital, we can see that all three growth rates increase on the transition paths (Figure 24). The growth rate of low human capital gain strength in period two, as teachers reduce their absent time and contribute more to teaching activities. Especially in regimes with weak punishment (the red lines with markers), the low human capital growth rates shoots up a lot on transition path before converge to levels higher than the original growth rates. Accomplishment in low human capital production also benefit the high human capital production, and thus the high human capital growth rate increase after period two. As raising teacher wage does not affect disposable income directly, saving and physical capital do not take a negative impact (different from the tax raise policy scenario).

How do GDP levels change on the transition path? Figure 25 displays changes in GDP when the teacher wage index rises. In all four regimes, production with high wage exceeds that with low wage within one or two period after the policy change. If teachers work less in the informal sector, the high-skilled labor force would shrink, which should have a negative impact on GDP. However, why do we not observe the GDP declining? We decompose the goods production into the levels of physical capital, low-skilled and high-skilled labor force. In Figures 26 and 27, the high-skilled labor decreases only by 1.63% and 0.83% in period one, while the physical capital and low-skilled labor remain the same. This is why the GDP level decreases only moderately. From period two, the lower education quality improves thanks to less teacher absenteeism, hence the enlarging low-skilled and high-skilled labor force. Moreover, the physical capital accumulation accelerates from period two. Therefore, GDP under a high teacher wage index overtakes that under a low index after the policy reform at t=1.

3.6.3 Increasing Punishment For Teacher Absenteeism

3.6.3.1 Balanced Growth Paths

Our last policy experiment is to impose stronger punishment for teacher absenteeism. Assumed in the previous sections, the financial penalties on absenteeism depend both on the absent length m and the punishment level ρ. If a teacher is found absent for a period of m, his pretax income from the teaching job will be discounted to $(1-\rho m)\tilde{w}\bar{h}$. Similar with previous policy exercises, the effects of rising punishment strength need to be considered under different policy regimes for taxes and teacher wages. We show results of the policy change under the following regimes:

(1) Low Tax ($\tau = 0.15$) and Low Wage ($\kappa = 0.8$);
(2) Low Tax ($\tau = 0.15$) and High Wage ($\kappa = 1.5$);
(3) High Tax ($\tau = 0.6$) and Low Wage ($\kappa = 0.8$);
(4) High Tax ($\tau = 0.6$) and High Wage ($\kappa = 0.8$).

Figure (28) displays responses of teacher absenteeism and GDP growth rates on balanced growth paths when the punishment level ρ rises from 0.7 to 1.4. Teachers' absent time decreases in all regimes. In the regime with low tax and low teacher wage, absenteeism falls from 0.81 to 0.44, a 44% drop; in the regime with low tax and high wage, it decreases from 0.49 to 0.28, a 41% drop; in the regime with high tax and low wage, it decreases from 0.82 to 0.40, a 49% cut; lastly, in the regime with high tax and high wage, it decreases from 0.46 to 0.24, a 46% drop. Therefore, teacher absenteeism is scaled back by similar amount in percentage terms. However, the initial absenteeism levels are different among four regimes. The two regimes with low wage both have an absent rate above 0.8 prior to the policy change. The other two regimes with high wage both have pre-reform absenteeism less than 0.5. After the punishment level increases to 1.4, the two regimes with low wage still show absenteeism above 0.4. The results reinforce the presumption that, several policy instruments need to be used simultaneously in order to achieve the optimal outcomes.

The GDP growth rates increase in all regimes. In the regime with low tax and low teacher wage, the GDP growth rate rises from 1.42 to 1.85, a 30.34% improvement; in the regime with low tax and high wage, it increases from 1.76 to 1.92, a 8.78% improvement; in the regime with high tax and low wage, it rises from 1.95 to 2.75, a 39.41% growth; lastly, in the regime with high tax and high wage, it increases from 2.65 to 2.93, a 9.98% growth. The two regimes with low teacher wage both have impressive performances in strengthening GDP growth rates; nevertheless, these escalating growth rates are partly a result of the very low initial levels.

3.6.3.2 Transition Paths

Figures (29) and (30) display adjustments of economic variables on the transition paths when the punishment level is raised from 0.7 to 1.4. Teacher absenteeism is reduced across different regimes on taxes and teacher wages. The GDP growth rates display a similar pattern regardless of taxes and teacher wages. When the punishment level is raised from 0.7 to 1.4, the GDP growth rates increase and converge to a higher level in the new equilibria. The regime with high tax and high teacher wage has the highest growth rates prior and after the policy shock: the growth rates are 2.65 and 2.93 in the old and new equilibria respectively. The regime with high tax and low wage has the best growth improvement: the growth rates are 1.95 and 2.75 in the old and new equilibria respectively. The higher education funding proportion stays fairly stable on the transition path as there is no adjustment in taxation.

The policy on punishment level benefit human capital accumulations. The growth rates of the low and high human capital both increase. Teachers scale back their absent time while contributing more to classroom activities. The hard work and dedication of teachers enhance the quality of basic education, evidenced in the enlarging low-skilled labor force $\underline{H}$. The improving basic education equips students with the necessary study skills and knowledge for the higher education, and therefore the high-skilled labor force $\overline{H}$ growth accelerates

Lastly, figure (31) shows GDP in the scenarios with and without changes in punishment level. The production with a higher punishment level exceeds that with a lower punishment level after the policy shock. Figures 32 and 33 decompose GDP into the levels of physical capital, low-skilled and high-skilled labor force. When the punishment level suddenly rises at t=1, teachers absenteeism decreases immediately and thus the high-skilled labor force decreases. Nevertheless, because teachers are only 5% in the group with high human capital, the reduction in teacher absenteeism only causes the high-skilled labor to decrease by 1.87% and 1.14% respectively. At t=1, only the high-skilled labor decreases by small amounts, while both physical capital and low-skilled labor force remain the same, for this reason GDP only decreases by 0.66% and 0.4% respectively. After the first period, the reduction in teacher absenteeism improves both low and high human capital production. Therefore, GDP under a higher punishment level overtakes that under a lower punishment level after the second period.

3.7 Conclusions

This paper formulates a model to study the mechanism through which policy reforms affect teacher absenteeism, economic growth, GDP, and the quality of low and high education. In a general equilibrium model, private agents are heterogeneous in their human capital, so that there are low-skilled workers, higher-skilled workers and school teachers. Under weak supervision and inadequate wage, teachers take the risk of being punished to work in informal jobs during school sessions. Furthermore, teachers can evade income taxes from informal jobs. We provide three policy experiments: raising the labor tax rate, increasing the teacher wage index, and increasing the punishment level on teacher absenteeism.

We find: first, a higher labor tax rate alleviates teacher absenteeism in most regimes, except in the regime with low teacher wage and low punishment level, in which increasing tax rate induces more teacher absenteeism. Second, increasing labor taxes improve the government funding for higher education and the quality of high human capital. In addition, raising labor taxes leads to absenteeism reduction in most cases, so that teachers spend more time to teaching activities and thus the quality of low human capital rises. On the other hand, physical capital accumulation suffers a short-term drop due to higher taxes. The compounding effect of a better educated labor force and temporarily decreasing physical capital is that GDP declines in the short run and catches up in the long run.

Second, when we increase the teacher wage index, absenteeism falls regardless of policy regimes on taxes and punishment level. In an economy with chronically inefficient supervision, increasing teacher wage helps cut down teacher absenteeism fast. Unlike the reform on tax rate, increasing teacher wage index has little effect on the higher education funding. Nevertheless, as teachers are absent less, they directly contribute to the low human capital production. Moreover, with good basic education, students are better prepared for higher education as well, and thus we also see improvement in high human capital production. Furthermore, the physical capital level remains stable due to no changes in tax rates. Therefore, on the transition path, GDP with a higher teacher wage index exceeds that with a lower index.

Lastly, when we increase the punishment level, teacher absenteeism declines and the GDP growth rate rises monotonically in all four regimes. Teachers draw back from informal jobs, which result in a temporary decline in high-skilled labor force. This negative effect on high-skilled labor force is small because of the low proportion of teachers in the population. As teachers become more dedicated to teaching duties, the quality of lower education and low-skilled labor increase. Better basic education indirectly improves the outcome of higher education, and thus the high-skilled labor force enlarges as well. Therefore, on the transition path, GDP with a higher punishment level overtakes that with a lower punishment level.

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CHAPTER IV

APPENDIX TO CHAPTER I

Table 1: Return Migrants, Non-migrants, and Migrants in China, 1999

	All	Non-migrants	Continuing migrants	Return migrants
No. of workers	2137	1673	289	175
%	100	$\boxed{78.3}$	$\boxed{13.4}$	$\boxed{8.3}$
Male(%)	52.0	47.8	63.3	73.6
Married(%)	83.3	89.5	48.6	80.9
Age (years)	39.6	42.0	27.9	35.6
Schooling (years)	6.0	$\boxed{5.5}$	$\boxed{7.7}$	$\boxed{7.1}$
Illiterate(%)	12.4	14.9	3.8	2.2
Primary school (%)	38.9	$\boxed{42.9}$	18.5	$\boxed{33.7}$
Junior high(%)	41.3	35.1	$\boxed{68.5}$	$\boxed{54.9}$
Senior high(%)	6.9	6.6	7.6	8.6
Technical school or higher(%)	0.6	0.4	1.0	1.1

Data Source: Survey, Ministry Of Agriculture(1999)

Table 2: Job Creation by the Returning Migrants

Type and scale	No. in Survey	No. of Employees	Financial resources
Manufacturing			
Large scale	27	16 to 860, median: 40	Some have formal loans, some partly owned by the gov.
Small scale	25	1 to 15, median: 4	Personal saving, informal loans
Services			
Small scale	22	1 to 13, median: 4	Personal Saving, informal loans

Data source: Murphy (1999, Pg. 146)

Table 3: Ratios of Rural Loans to Deposits

	L/D			ACLD/OLs		
Year	Total	ABC	RCCs	ABC	RCC	ADBC
1985	1.85	0.45				
1986	1.63	0.46				
1987	1.56	0.46				
1988	1.54	0.47				
1989	1.11	0.43	0.66			
1990	1.07	0.39	0.66			
1991	1.05	0.37	0.67	1.43	1.43	
1992	1.02	0.35	0.71	1.31	1.40	
1993	1.01	0.34	0.76	1.15	1.33	
1994	1.06	0.26	0.73	0.86	1.51	
1995	1.12	n/a	0.73	1.07	1.16	0.90
1996	1.14	n/a	0.72	1.21	1.25	0.96
1997	1.13	0.15	0.69	1.13	1.20	0.88
1998	1.09	0.16	0.68	0.77	0.95	0.73
1999	1.06	0.59	0.69	0.64	0.94	0.54
2000	0.94	0.45	0.69	0.66	0.91	0.80
2001	0.90	0.40	0.69	0.74	0.96	0.45
2002	0.86	0.18	0.70	0.75	1.02	0.24
2003	0.82	0.16	0.72	0.88	1.12	0.25
2004	0.79	0.14	0.70	0.83	1.19	0.34

Resource: Almanac of China's Finance and Banking (1986-2005);
ADBC internal report; Jia (2007)

L/D: Outstanding of loans divided by outstanding of deposits.

ACLD: Annual cumulative loan disbursement.

OLs: Outstanding of loans.

ABD: Agricultural Bank of China.

ADBC: Agriculture and development bank of China.

Table 4: Rural and urban population in China from 1978 to 2002

Population	1978		2002		Change	
	Million	%	Million	%	Million	%
Urban	159	17%	502	39%	343	129.41%
Rural	803	83%	782	61%	-21	26.50%
Total	963	100%	1,285	100%	322	

Data source: China statistical year book, 2003
Data in this table exclude the popualation of Hong Kong SAR, Macao SAR and Taiwan

Table 5: Parameters used for China's economy

Parameter	Meaning	Value
A_f	TFP in rural farm sector in 1978	2
A_e	TFP in rural non-farm sector in 1978	3
A_u	TFP in urban sector in 1978	3.2
λ	TFP growth rate in rural farm sector	2.65
μ	TFP growth rate in rural non-farm sector	$2.1877 = 1.0158^{20}$
ζ	TFP growth rate in urban sector	$2.0765 = 1.0372^{20}$
w_{u0}	Urban wage in 1978	1.4473
ρ	Urban wage growth rate	$2.84 = 1.05^{20}$
ν	parameter in human capital distribution	[-0.2 1.2]
σ	parameter in human capital distribution	0
τ	Migration cost	[0,0.2], 0.15 for China
α	$\frac{\alpha}{\alpha+\beta}$: income share of capital in hired factors in rural non-farm sector	0.25
β	$\frac{\beta}{\alpha+\beta}$: income share of labor in hired factors in rural non-farm sector	0.3
η	Income share of land in farm sector	0.6
γ	Income share of capital in urban sector	0.3
r	Real interest rate	$1.66 = 1.0257^{20}$

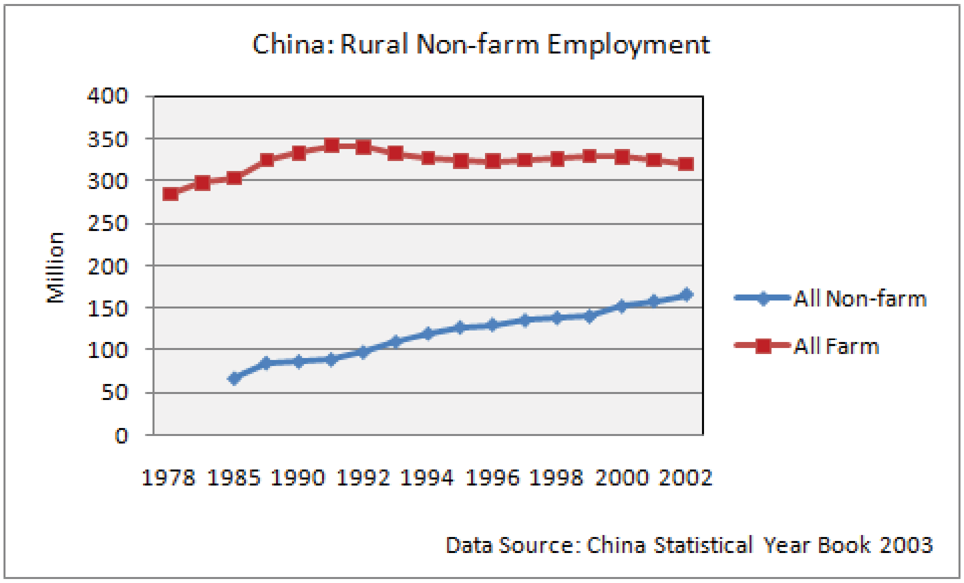

Figure 1: Rural Farm and Non-farm Employment in China, 1978-2002

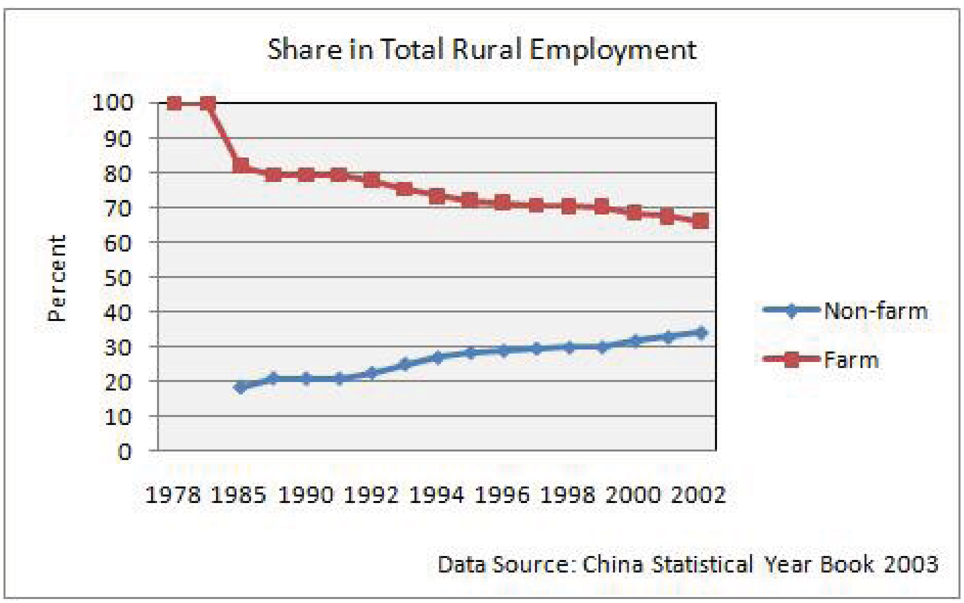

Figure 2: Farm and Non-farm Share in Total Rural Employment, 1978-2002

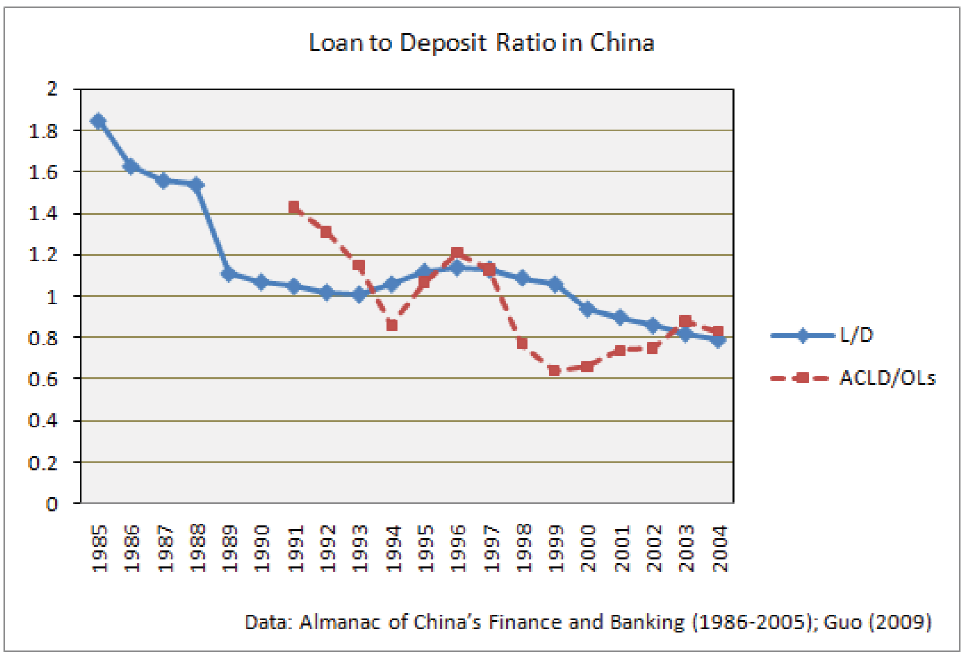

Figure 3: Loan to Deposit Ratio in Rural China

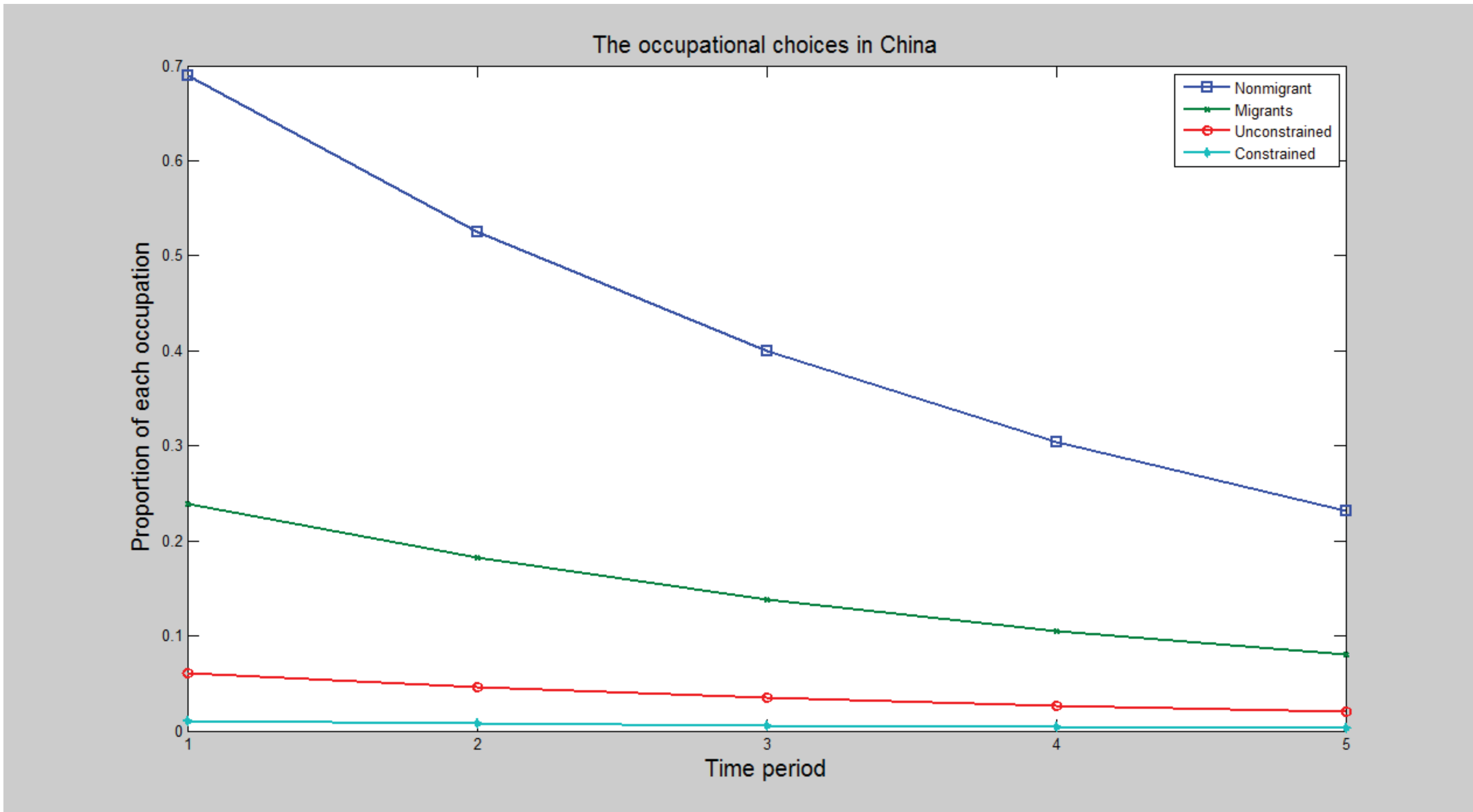

Figure 4: (China) The population of rural residents in each occupation. Note:The total rural population in period 1 is one. The migration rate (green) 26.44% matches migration data in China (table (4)).

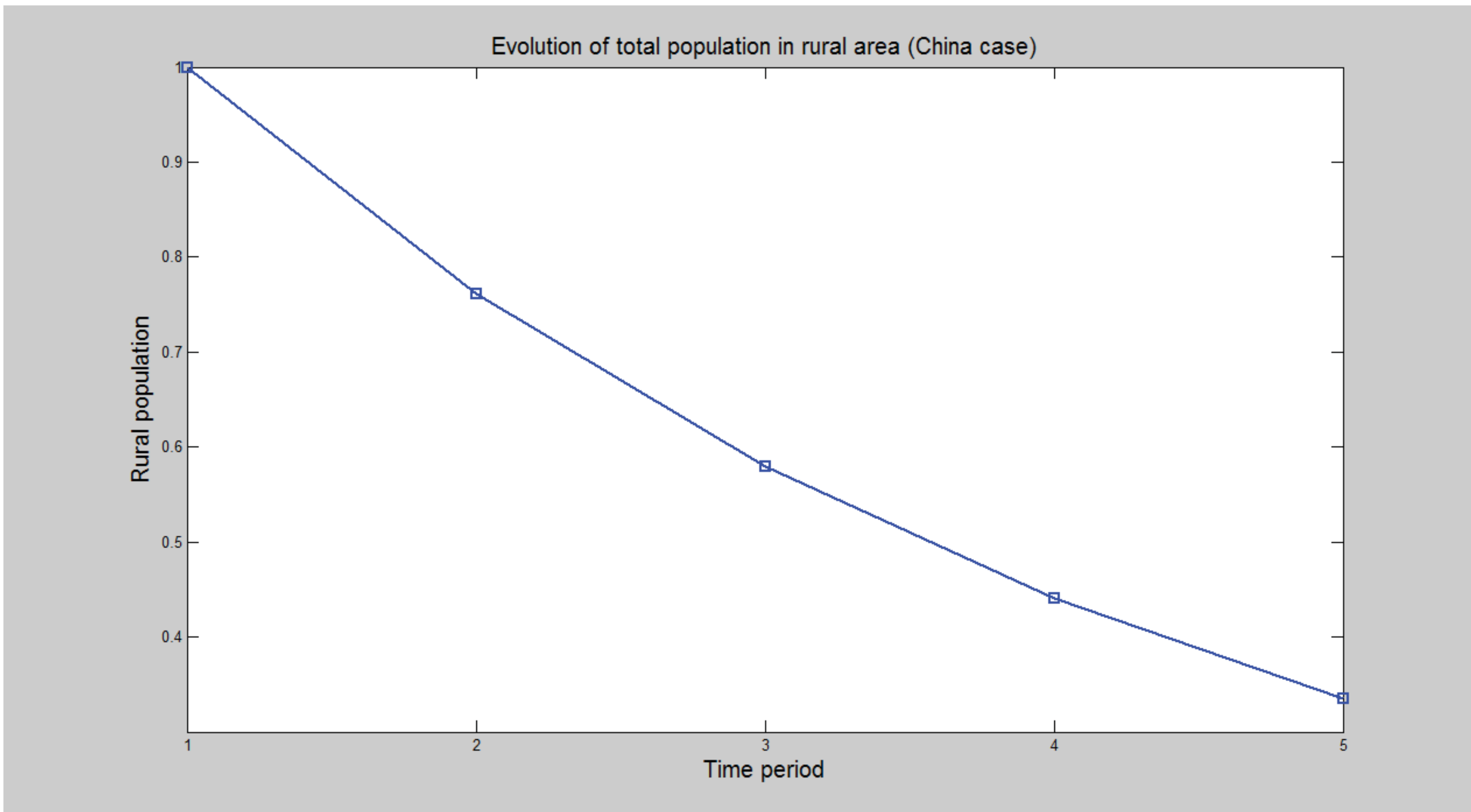

Figure 5: (China) Total rural population evolution. One period is 20 years and the rural population in the first period is normalized to one.

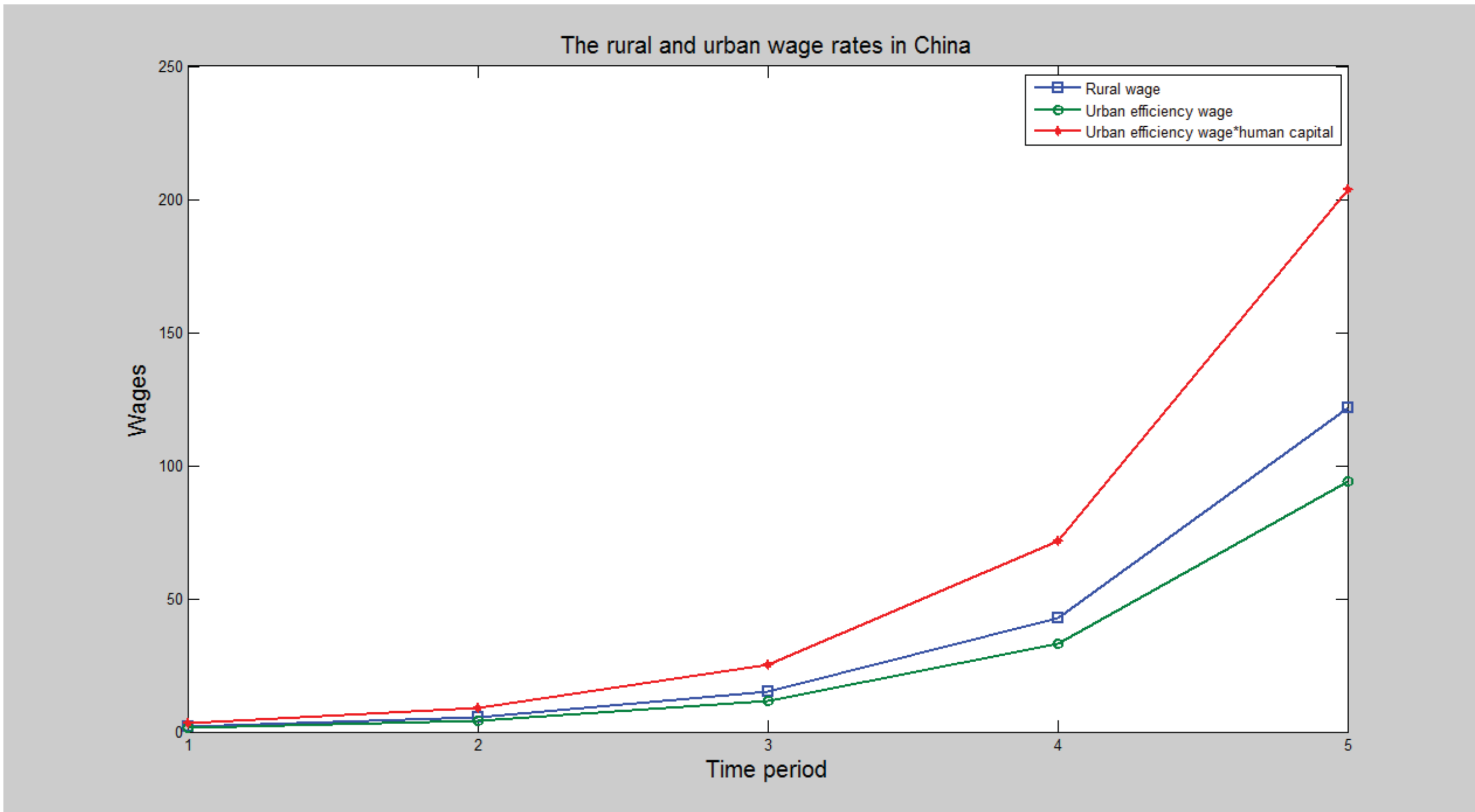

Figure 6: (China) Rural and urban wage evolution. On the balanced growth path, the rural and urban wages are growing at the same rate.

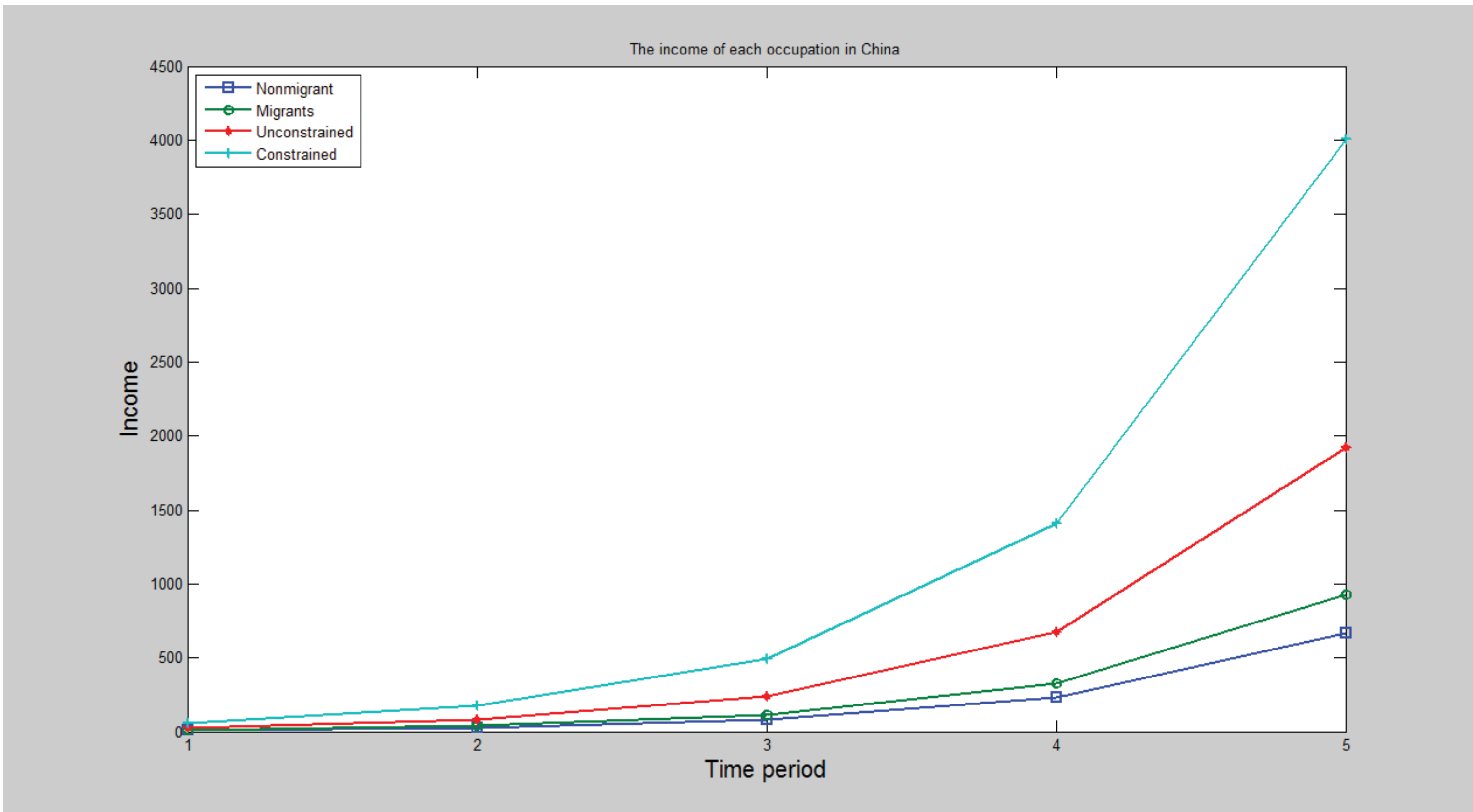

Figure 7: (China) The evolution of median income of each occupation. On the balanced growth path, the median income of constrained entrepreneurs is about 6 times that of non-migrants, and the median income of permanent migrants is about 1.4 times that of non-migrants.

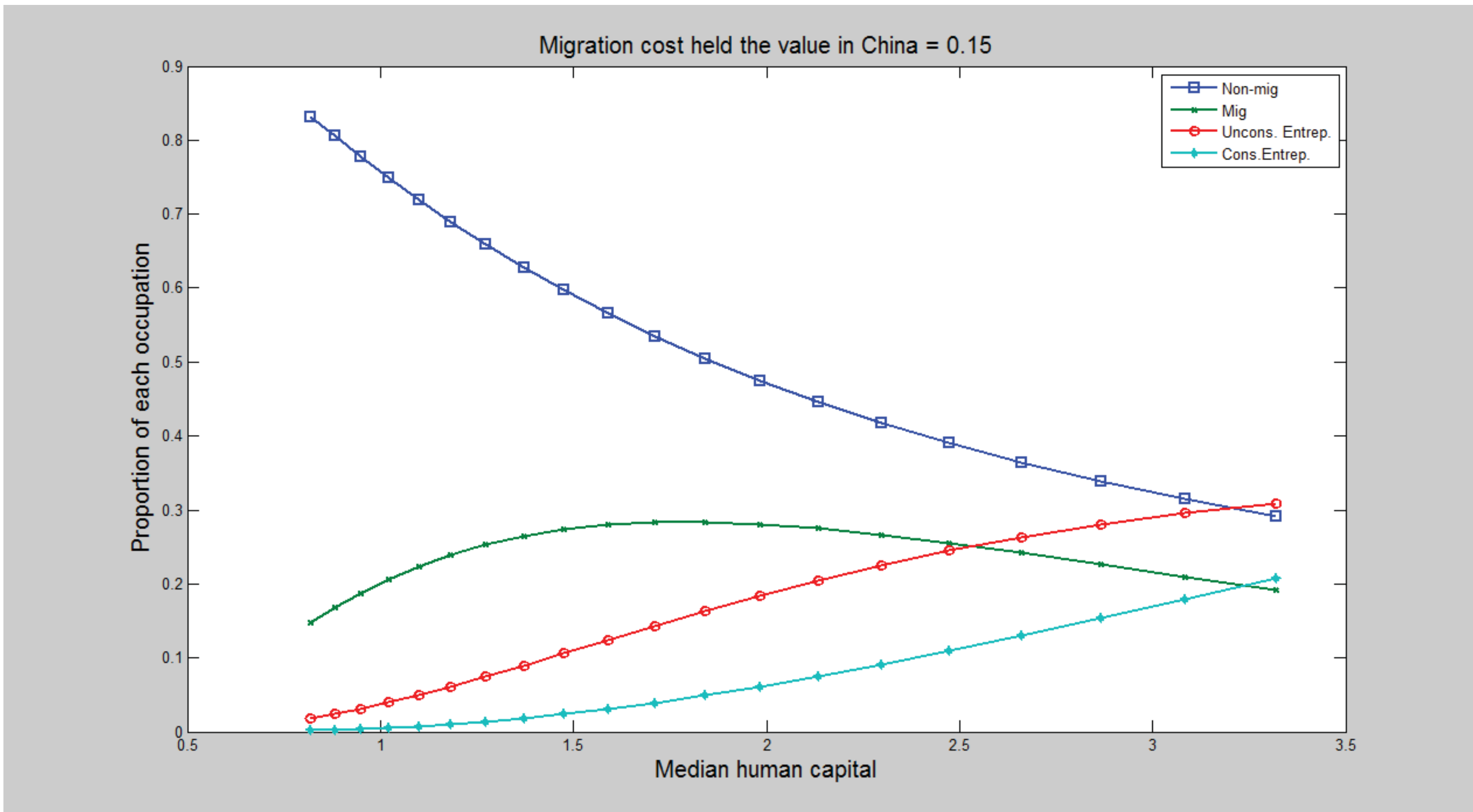

Figure 8: (China) The proportion of each occupation and the median human capital. When the median human capital increases, % of non-migrants drops, % of migrants rises followed by decreases, % of entrepreneurs rises.

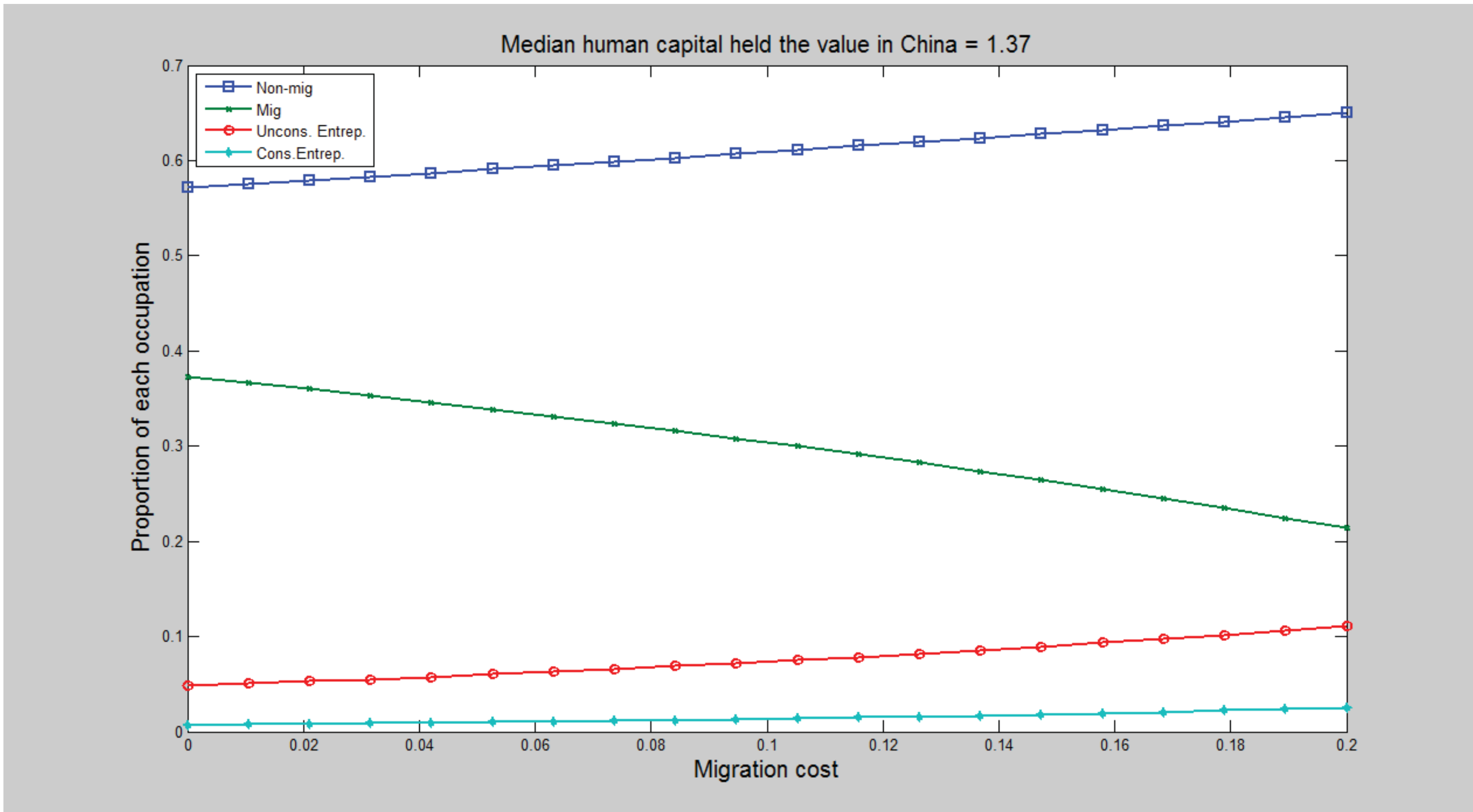

Figure 9: (China) The population in each occupation and migration cost. When migration cost increases, the group of migrants drops whereas the groups of non-migrants and entrepreneurs both enlarge.

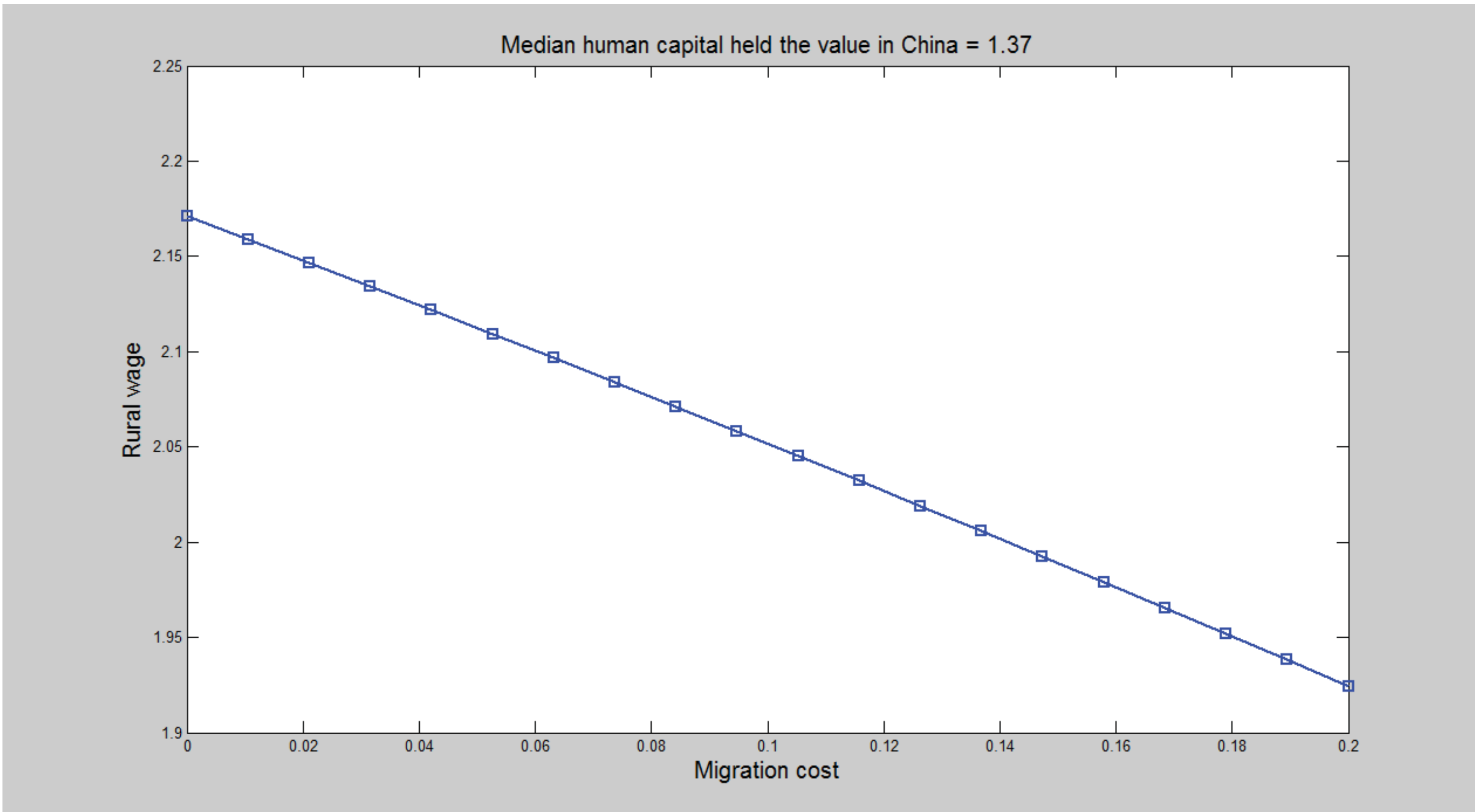

Figure 10: (China) The rural wage and migration cost. As migration cost increases, the rural wage drops.

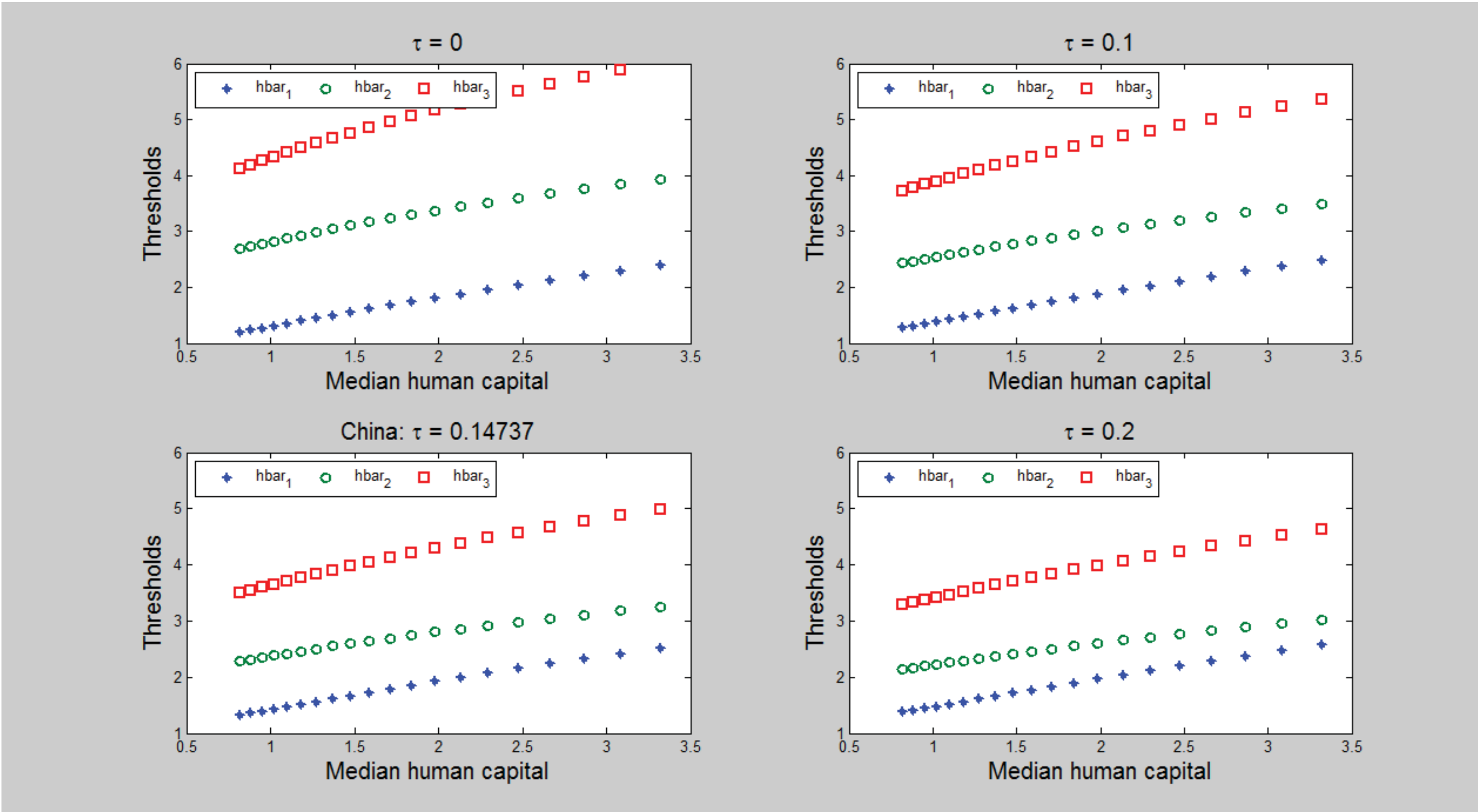

Figure 11: Thresholds and median human capital

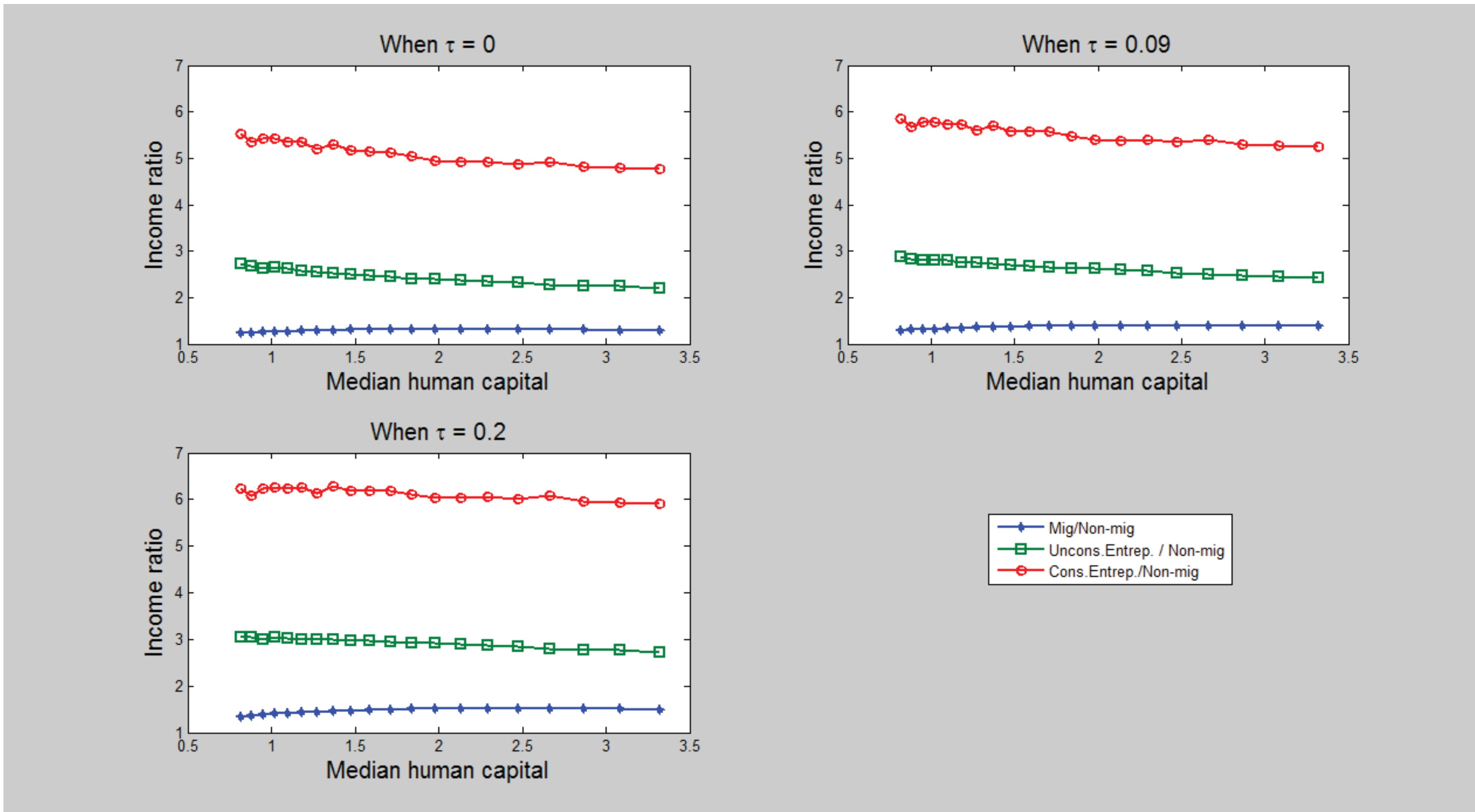

Figure 12: Income ratio and median human capital

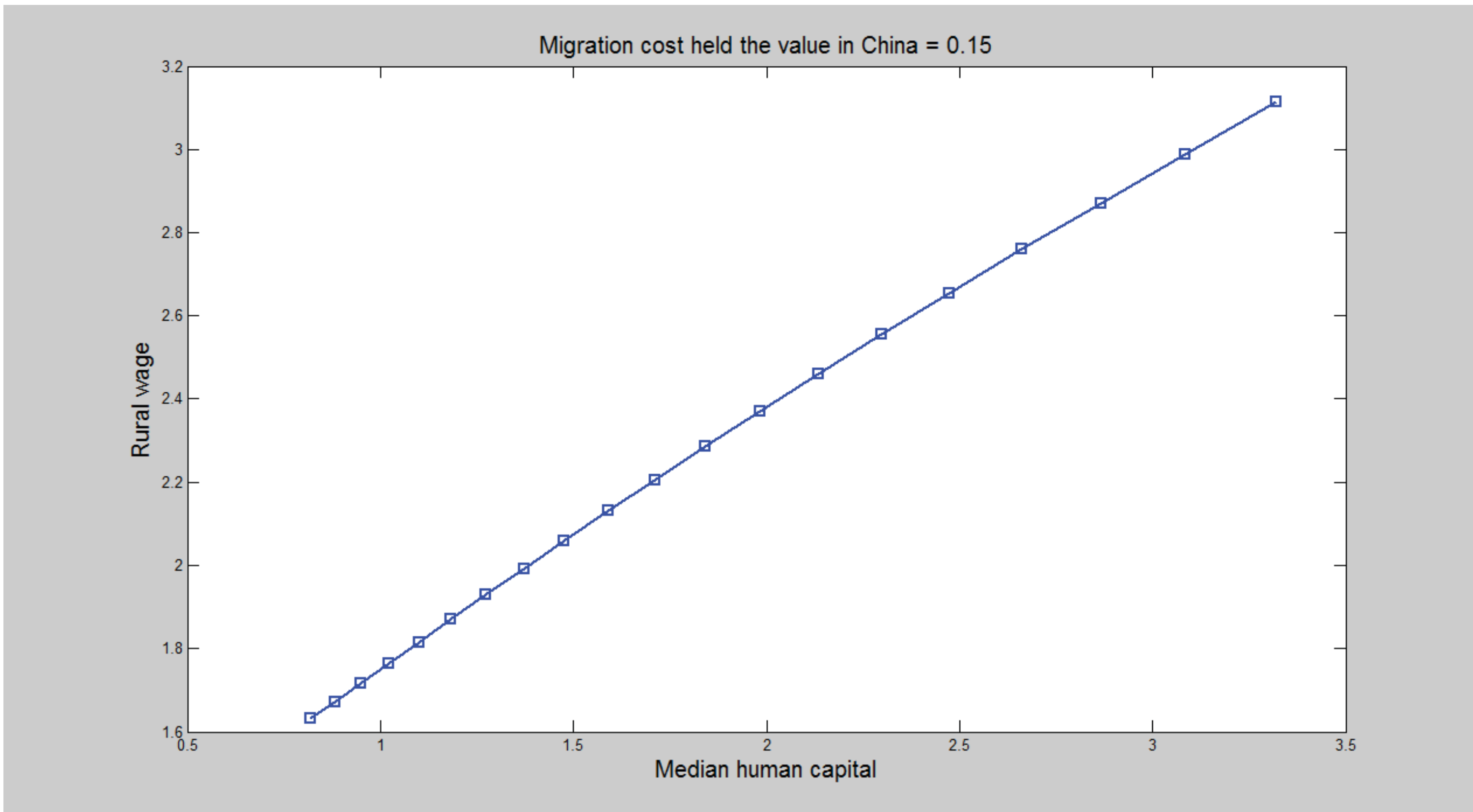

Figure 13: Rural wage and median human capital. As median human capital increases, rural wages also rises, keeping other things unchanged.

CHAPTER V

APPENDICES TO CHAPTER II

Appendix A: MLS Estimation Algorithm

1. Guess the starting value for $\Lambda = \{\Theta_1, \Theta_2, \sigma_{\alpha_1}, \sigma_{\alpha_2}, \rho_\alpha, \rho_u\}$

2. Given $\{\sigma^2_{\alpha_1}, \sigma^2_{\alpha_2}, \rho_\alpha\}$, generate S pairs of bivariate normal random variables for household i: $\{(\alpha^{(1)}_{1i}, \alpha^{(1)}_{2i}), (\alpha^{(2)}_{1i}, \alpha^{(2)}_{2i}), ...(\alpha^{(S)}_{1i}, \alpha^{(S)}_{2i})\}$

3. Given Λ and $\{\alpha^{(s_1)}_{1i}, \alpha^{(s_2)}_{2i}\}^S_{s_1=s_2=1}$, the individual likelihood function (2.2.17) can by approximated by the simulated likelihood function:

$$\hat{\ell}_i = \frac{1}{S}\sum_{s_1=s_2=1}^{S}\{\Pi_{t=1}^{T}\Phi[q_{1,it}(\mathbf{w}_{it}\Theta_1 + \alpha^{(s_1)}_{1,i}), q_{2,it}(\mathbf{w}_{it}\Theta_2 + \alpha^{(s_2)}_{2,i}); q_{1,it}q_{2,it}\rho_u]\} \quad (5.0.1)$$

4. Given the independence over i, the simulated log-likelihood for all individuals is given by:

$$\begin{aligned} ln\hat{L}_N(\Lambda) &= \sum_{i=1}^{N} ln\hat{\ell}_i \\ &= \sum_{i=1}^{N} ln\frac{1}{S}\sum_{s_1=s_2=1}^{S}\{\Pi_{t=1}^{T}\Phi[q_{1,it}(\mathbf{w}_{it}\Theta_1 + \alpha^{(s_1)}_{1,i}), q_{2,it}(\mathbf{w}_{it}\Theta_2 + \alpha^{(s_2)}_{2,i}); q_{1,it}q_{2,it}\rho_u]\} \end{aligned} \quad (5.0.2)$$

5. Maximize simulated log-likelihood $ln\hat{L}_N(\Lambda)$ with respected to Λ.

6. Use the estimated value for Λ, and go back to repeat steps 2 - 5 until convergence is achieved.

Appendix B: Partial Questionnaire Relevant for This Paper

Variable Code	Variable Definition
020	Number of labors in this household
022	Of rural labors, how many are male
023	Of rural labors, how many are illiterate
024	Of rural labors, how many are elementary school graduate
025	Of rural labors, how many are secondary school graduate
026	Of rural labors, how many are high school graduate and above
043	Arable land in year end
051	Total original value of assets for production by year end (yuan)
124	Revenue from household-run planting (yuan)
129	Revenue from household-run forestry (yuan)
130	Revenue from household-run husbandry (yuan)
131	Revenue from household-run fishery (yuan)
132	Revenue from household-run manufactory industry (yuan)
133	Revenue from household-run construction (yuan)
134	Revenue from household-run transportation (yuan)
135	Revenue from household-run retailing, restaurants, and other services (yuan)
136	Revenue from other household-run non-farm business
143	Cost of household-run planting (yuan)
148	Cost of household-run forestry (yuan)
149	Cost of household-run husbandry (yuan)
150	Cost of household-run fishery (yuan)
151	Cost of household-run manufactory industry (yuan)
152	Cost of household-run construction (yuan)
153	Cost of household-run transportation (yuan)
154	Cost of household-run retailing, restaurants, and other services (yuan)
155	Cost of other household-run non-farm business
178	Waichu Laowu Shouru (Income or remittances from migration activities)
275	Total deposits in year end
sm	Provinces:
	Hinterland: Shanxi, Jilin, Anhui, Henan, Hunan, Sichuan, Gansu
	Costal Provinces: Jiangsu, Zhejiang, Guangdong

Table 6: Occupation Division of Rural Households

Year	Farm (%)	Non-farm (%)
1995	80.68	19.32
1996	80.66	19.33
1997	77.41	22.59
1998	75.58	24.41
1999	73.95	26.04

Table 7: Percentage of Rural Households Receiving migration remittances

Year	Migration (%)
1995	40.43
1996	42.03
1997	43.13
1998	44.57
1999	47.67

Table 8: Occupation Switching of Rural Households

		$t = 1$		
		Farm	Non-farm	Total
$t = 0$	Farm	16,191	1,547	17,738
	(%)	(91.28)	(8.72)	(100.00)
	Non-farm	1,167	3,667	4,834
	(%)	(24.14)	(75.86)	(100.00)
	Total	17,358	5,214	22,572
	(%)	(76.90)	(23.10)	(100.00)

Table 9: Summary Statistics on Demographic Characteristics, 1995-1999

Name	Mean	Se.
Households size	4.30	1.58
Number of labor	2.61	1.10
Male (%)	54.17	21.39
Education (%)		
Illiterate	15.29	25.98
Elementary	40.06	33.73
Secondary	37.08	33.58
High school	7.55	19.41

Data: RCRE survey data

Table 10: Summary Statistics on Occupations and Income, 1995-1999

	Major in Farming			Major in Non-farm		
	mean	se	median	mean	se	median
Production Asset						
Farm	$\boxed{700.79}$	3560.38	192.00	356.09	1738.01	51.61
Nonfarm	718.88	2784.50	144.57	$\boxed{4532.76}$	14155.15	737.50
Revenue						
Farm	$\boxed{3190.44}$	4059.60	2447.15	1483.58	2184.21	1066.33
Nonfarm	739.96	4047.85	60.00	$\boxed{8593.22}$	18433.82	3570.83
Income						
Farm	$\boxed{1827.64}$	1439.40	1523.30	829.24	1086.56	654.15
Nonfarm	451.57	2439.13	40.00	$\boxed{4454.42}$	7107.82	2421.67
Other wage	271.79	854.08	0.00	162.54	554.66	0.00
Migration	$\boxed{865.36}$	1555.70	369.07	$\boxed{1268.92}$	3657.44	309.00

Data: RCRE survey data

Note: All in 1995 Chinese Yuan. 1 US Dollar = 8.28 Yuan (1995)

Table 11: Correlations between Different Sources of Income

Income Source	Farm	Nonfarm	Migration
Farm	1.0000		
Nonfarm	-0.1456	1.0000	
Migration	-0.1442	0.3394	1.0000

Table 12: Univariate Probit Model Estimation for migration remittances and Business Ownership

	Migration Eq.		Non-farm Eq.	
Varaibles	Coeff.	S.E.	Coeff.	S.E.
Constant	-1.7140***	(.1198)	-1.9390***	(.1010)
Mig($t-1$)	0.8583***	(.0333)	-0.1233***	(.0325)
Busi($t-1$)	-0.1183***	(.0397)	1.0410***	(.0525)
Education	0.1084***	(.0299)	0.0977***	(.0278)
Male fraction	0.1510**	(.0587)	0.0805	(.0766)
Number of labor	0.2493***	(.0307)	0.0015	(.0133)
Ln(Prod. assets($t-1$))	-0.0215***	(.0056)	0.0185***	(.0070)
Ln(Deposit($t-1$))	-0.0057	(.0043)	-0.0027	(.0045)
Coastal areas	0.0883**	(.0433)	0.4477***	(.0397)
Avg.Land	-0.0488***	(.0078)	-0.0624***	(.0116)
Mig(0)	1.1260***	(.0500)	-0.0943**	(.0422)
Busi(0)	-0.1254**	(.0537)	1.3800***	(.0910)
σ_α	.8242***	(.0310)	.7912***	(.0409)
$\sigma^2_\alpha/(1+\sigma^2_\alpha)$	.4045		.3850	
Log Likelihood	-10350		-7395	
N	22504		22504	

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Bivariate Probit Model Estimation for migration remittances and Business Ownership

	Migration Eq.		Non-farm Eq.	
Varaibles	Coeff.	S.E.	Coeff.	S.E.
Constant	-1.6252***	(0.0850)	-1.7306***	(0.0921)
Mig$(t-1)$	0.9630***	(0.0398)	-0.1794***	(0.0526)
Bus$(t-1)$	-0.2544***	(0.0548)	1.2974***	(0.0608)
Education	0.0993***	(0.0227)	0.0912***	(0.0231)
Male Fraction	0.1462**	(0.0625)	0.0669	(0.0657)
Number of labor	0.2319***	(0.0134)	-0.0021	(0.0125)
Ln(Prod. assets$(t-1)$)	-0.0188***	(0.0058)	0.0130**	(0.0057)
ln(Deposit$(t-1)$)	-0.0048	(0.0035)	-0.0037	(0.0036)
Costal areas	0.0851***	(0.0352)	0.3755***	(0.0359)
Avg. land holding	-0.0497***	(0.0068)	-0.0545***	(0.0065)
Mig(0)	0.9669***	(0.0530)	-0.0379	(0.0413)
Busi(0)	0.0241	(0.0526)	0.9592***	(0.0821)
σ_{α_1}	0.6886***	(0.0368)	0.5777***	(0.0731)
ρ_α	0.2450***	(0.0643)		
ρ_u	-0.4071***	(0.0315)		
Log-likelihood	-17696.6			
N	22504		22504	
Households	5626		5626	

Table 14: Average Partial Effects Estimation

	Migration Eq.		Non-farm Eq.	
Varaibles	Coeff.	S.E.	Coeff.	S.E.
Mig($t-1$)	.2647***	(.0089)	-.0179***	(.0049)
Busi($t-1$)	-.0293***	(.0052)	.2355***	(.0339)
Mig(0)	.3643***	(.0011)	-.0137***	(.0008)
Busi(0)	-.0311***	(.0031)	.3552***	(.0344)
Education	.0269***	(.0066)	.0141***	(.0046)
Male fraction	.0374***	(.0019)	.0117***	(.0018)
Number of labor	.0618***	(.0071)	.0002	(.0026)
ln(Prod.Asset($t-1$))	-.0053***	(.0007)	.0027***	(.0005)
ln(Deposit($t-1$))	-.0014*	(.0007)	-.0004	(.0004)
Coastal areas	.0220	(.0187)	.0725***	(.0045)
Avg.land holding	-.0121**	(.0048)	-.0090***	(.0004)

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

CHAPTER VI

APPENDIX TO CHAPTER III

Table 15: Parameters Values

Technology			
	Consumption Goods		
		A	5
		θ	0.50
		α_1	0.65
		α_2	0.35
		ϕ	0.75
	Human capital		
		B_1	10
		B_2	10
		γ_1	0.5
		γ_2	0.5
		η_1	0.5
		η_2	0.5

Table 16: Parameters Values (Cont.)

Population			
	Unskilled labor	$\underline{\pi}$	0.7
	Skilled labor	$\overline{\pi}$	0.3
	Teachers out of skilled labor	ζ	0.05
Punishment			
		ρ	[0.7,1.4]
		ψ	1.5
Wage index			
		κ	[0.8,1.5]
Tax rate			
		τ	[0.15,0.60]
$\frac{GovConsumption}{HigherEduFunding}$			6

Table 17: Balanced Growth Paths When Tax Rate Increases

		Teacher Wage Index	
		Low	High
	Weak	Absence ↑ 1.26%	Absence ↓ 4.56%
		GR ↑ 54.12%	GR ↑ 76.41%
Punishment			
	Strong	Absence ↓ 7.40%	Absence ↓ 11.95%
		GR ↑ 62.64%	GR ↑ 78.84%

Table 18: Balanced Growth Paths When Teacher Wage Index Increases

		Punishment on Absence	
		Low	High
Tax	Low	Absence $\downarrow$ 38.28% GR $\uparrow$ 22.02%	Absence $\downarrow$ 34.79% GR $\downarrow$ 1.85%
	High	Absence $\downarrow$ 42.41% GR $\uparrow$ 35.17%	Absence $\downarrow$ 38.85% GR $\uparrow$ 6.61%

GR: growth rate

Table 19: Balanced Growth Paths When Punishment Measure Increases

		Teacher Wage Index	
		Low	High
Tax	Low	Absence $\downarrow$ 43.95% GR $\uparrow$ 30.35%	Absence $\downarrow$ 40.83% GR $\uparrow$ 8.78%
	High	Absence $\downarrow$ 49.33% GR $\uparrow$ 39.41%	Absence $\downarrow$ 46.25% GR $\uparrow$ 9.98%

GR: growth rate

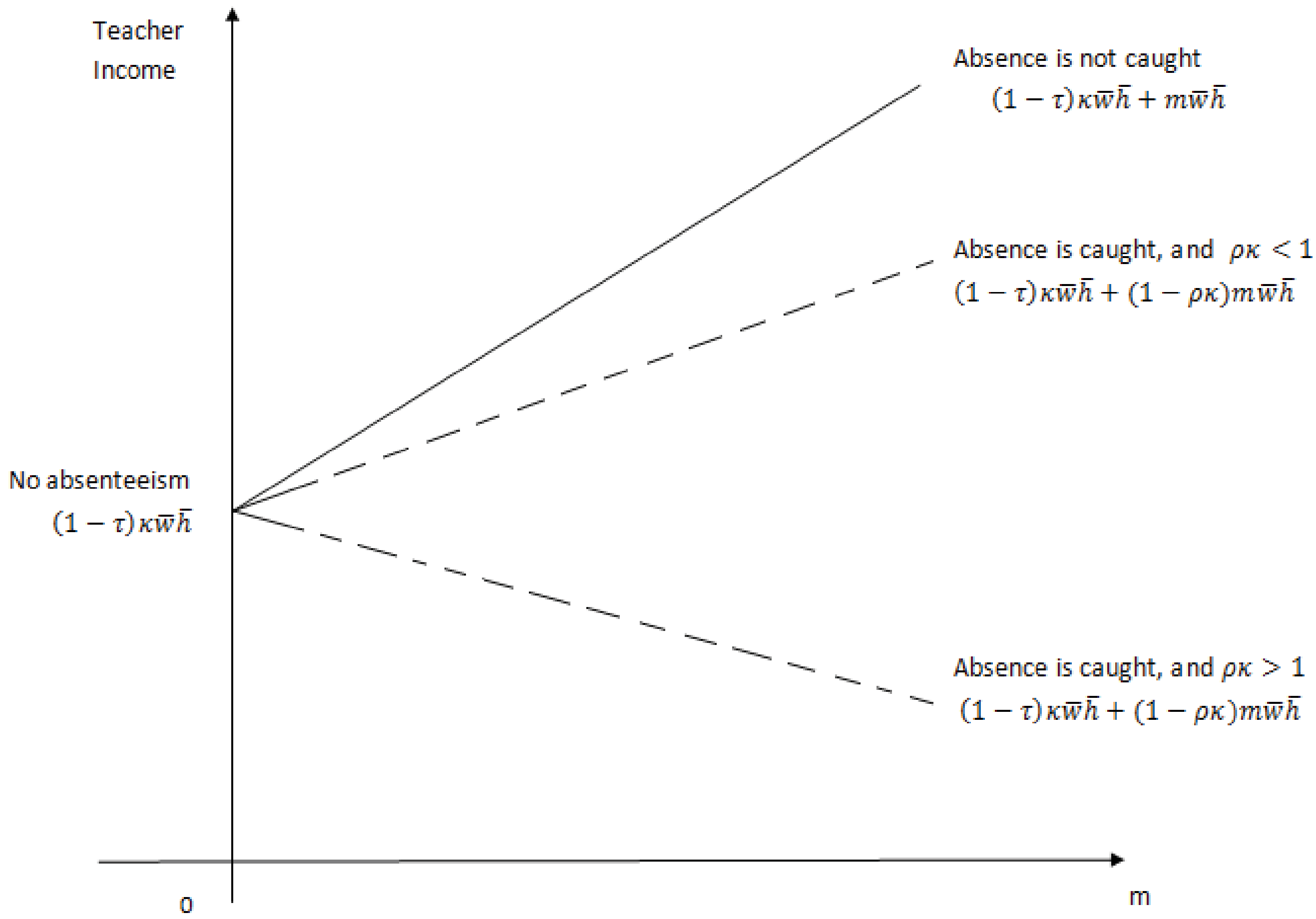

Figure 14: Teacher Absenteeism and Income

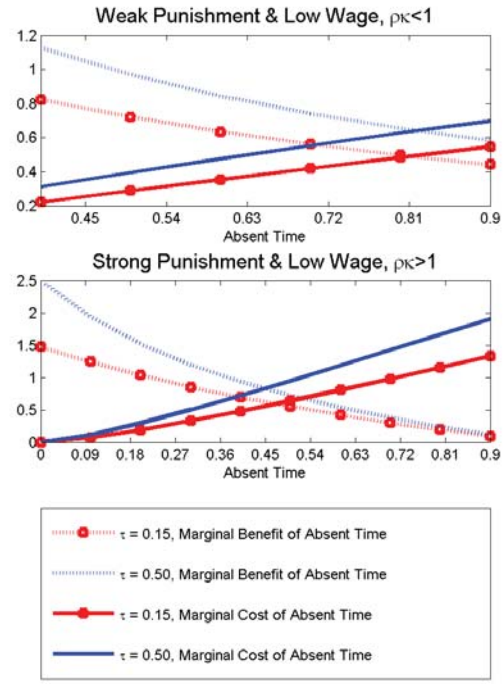

Figure 15: Marginal Cost and Marginal Benefit of Teacher Absence

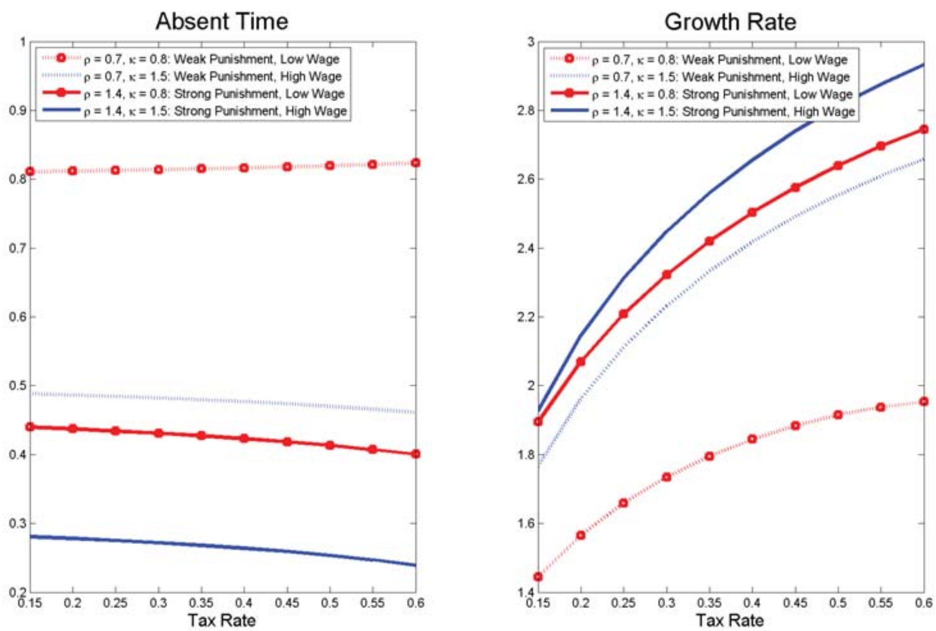

Figure 16: Balanced Growth Paths When Tax Rate Rises

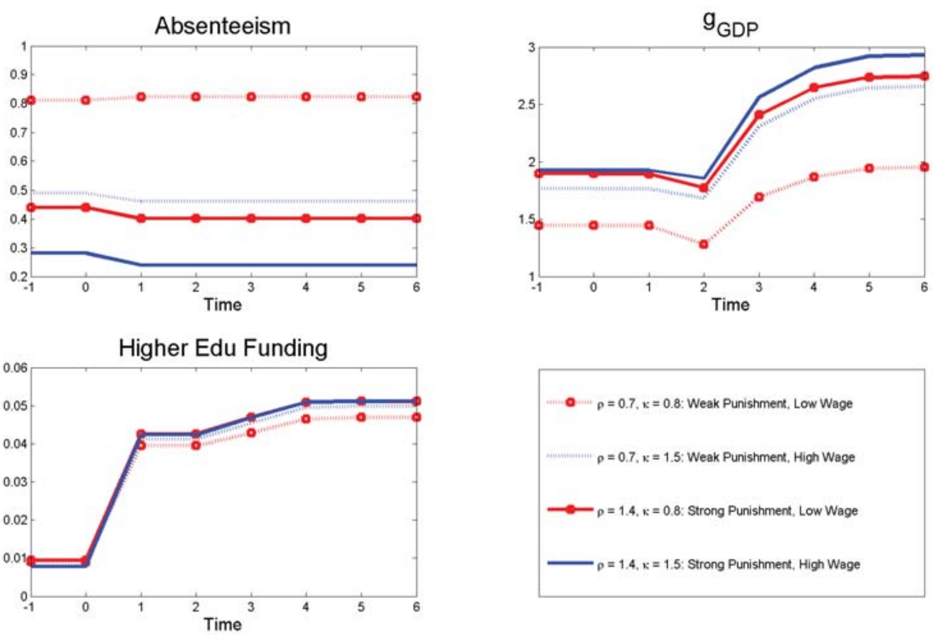

Figure 17: Transition Paths When Tax Rate Rises

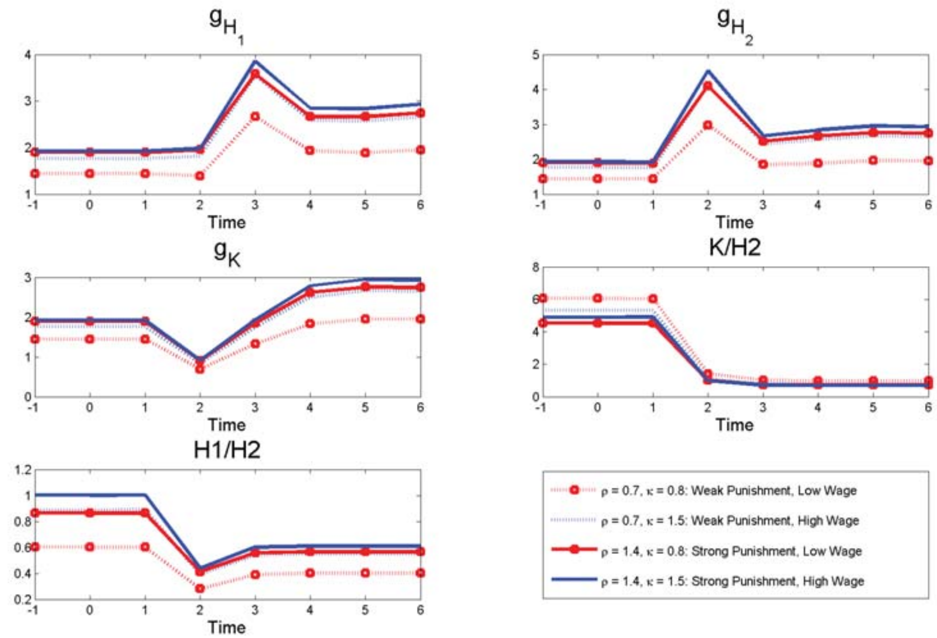

Figure 18: Transition Paths When Tax Rate Rises

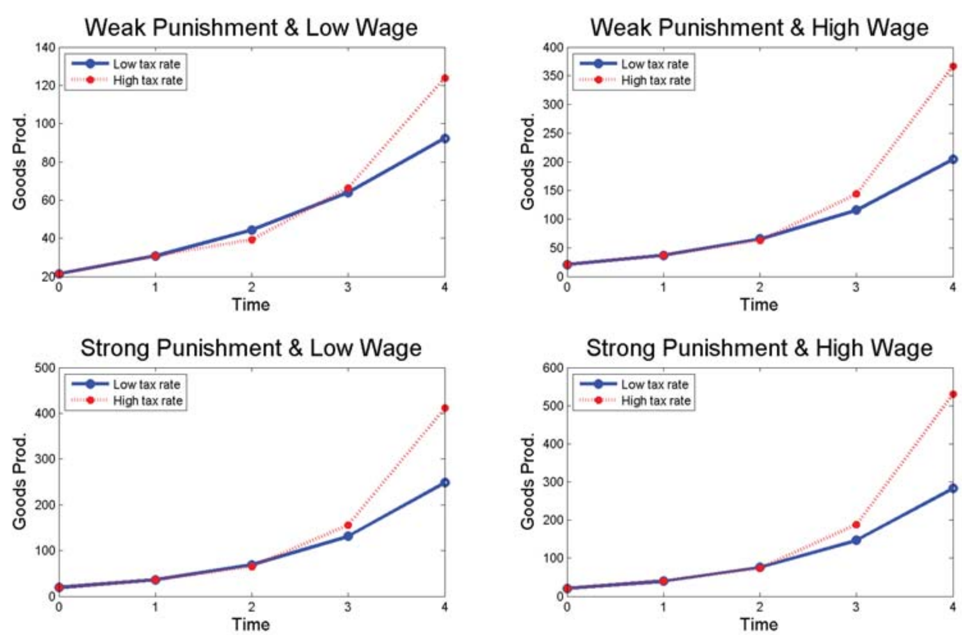

Figure 19: Levels of Goods Production at Transition When Tax Rate Rises

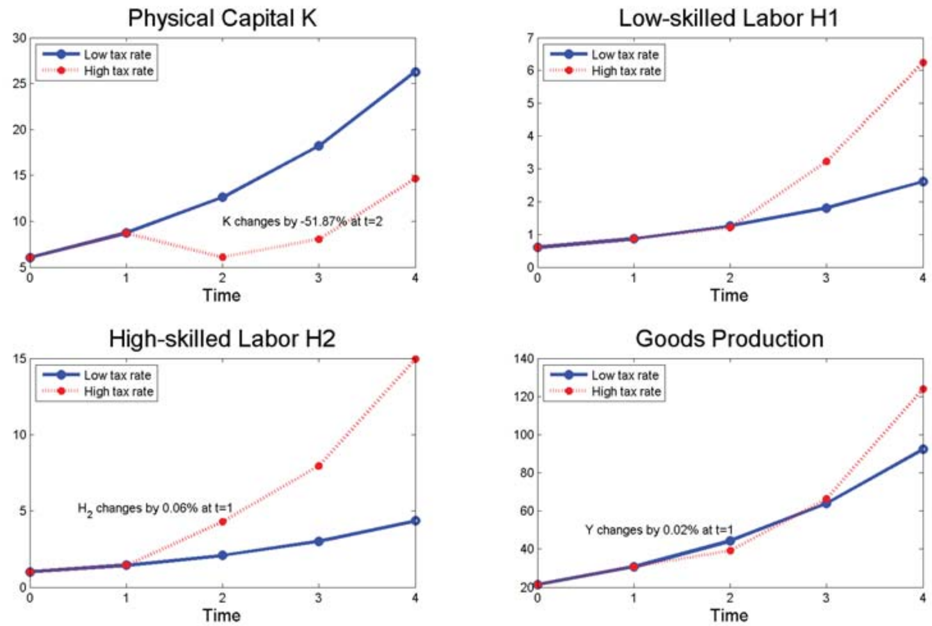

Figure 20: Change in Levels at Transition; Regime One: Weak Punishment and Low Wage.

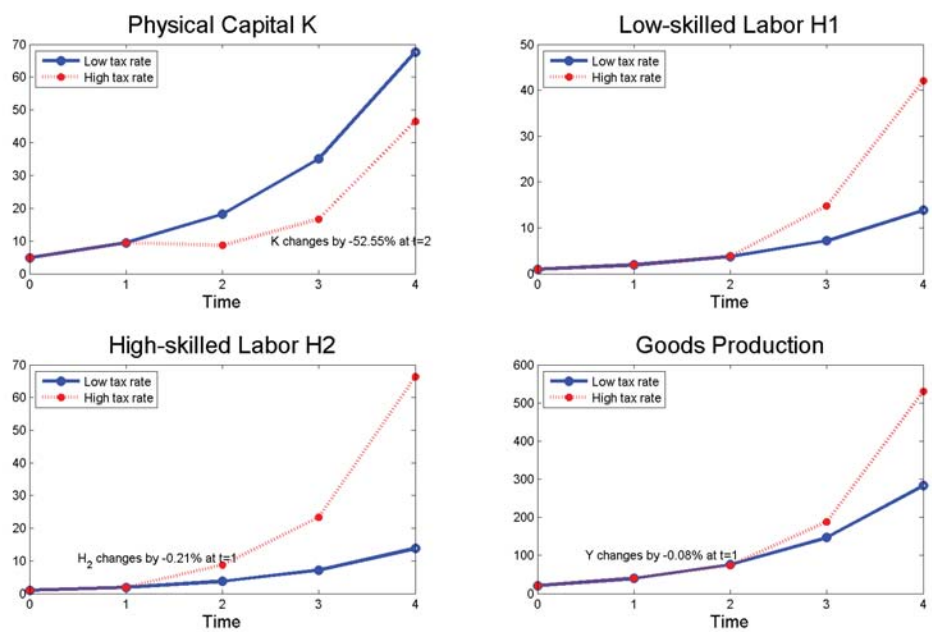

Figure 21: Change in Levels at Transition; Regime Four: Strong Punishment and High Wage.

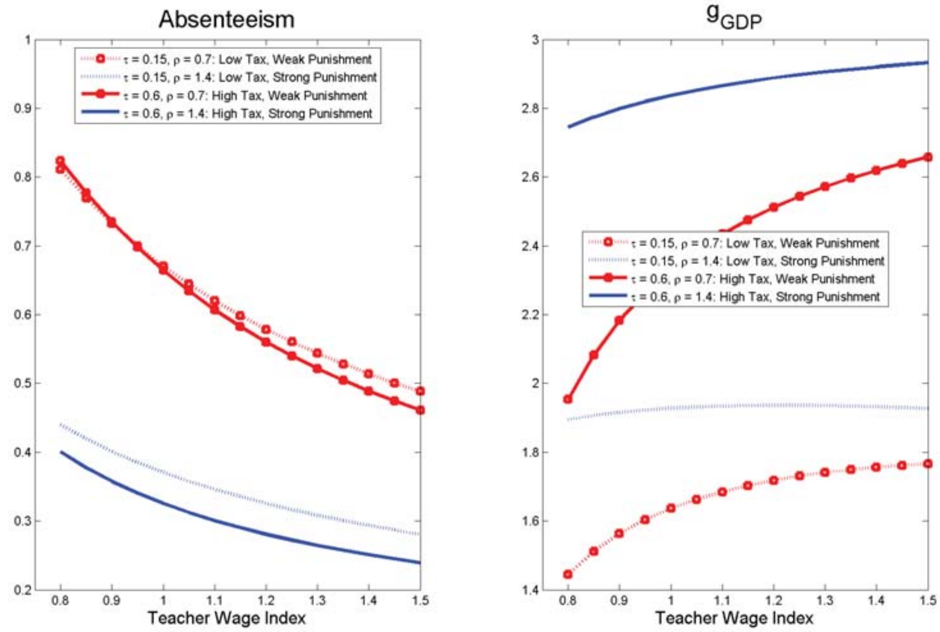

Figure 22: Balanced Growth Paths with Rising Teacher Wages

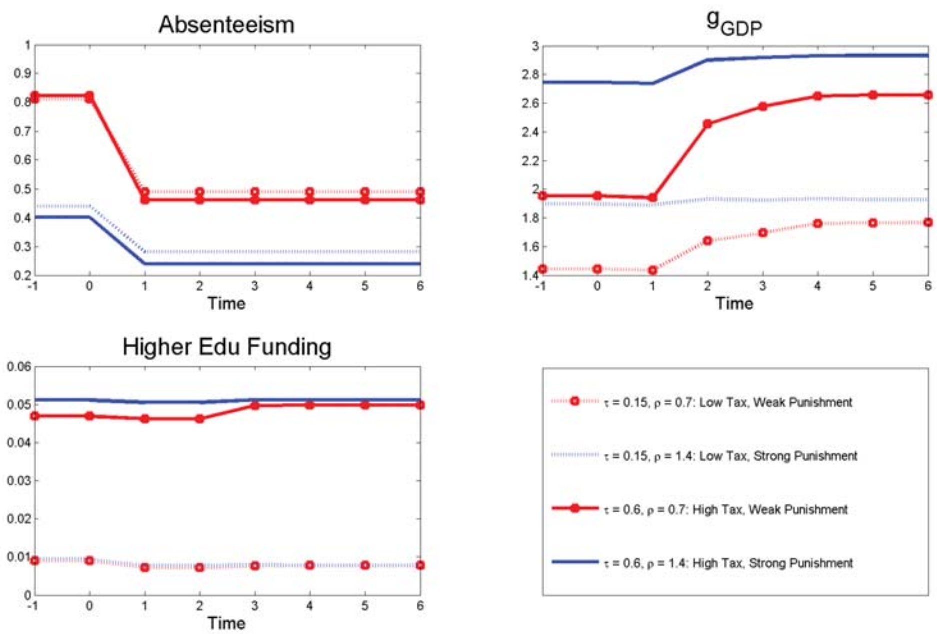

Figure 23: Transition Paths with Rising Teacher Wages

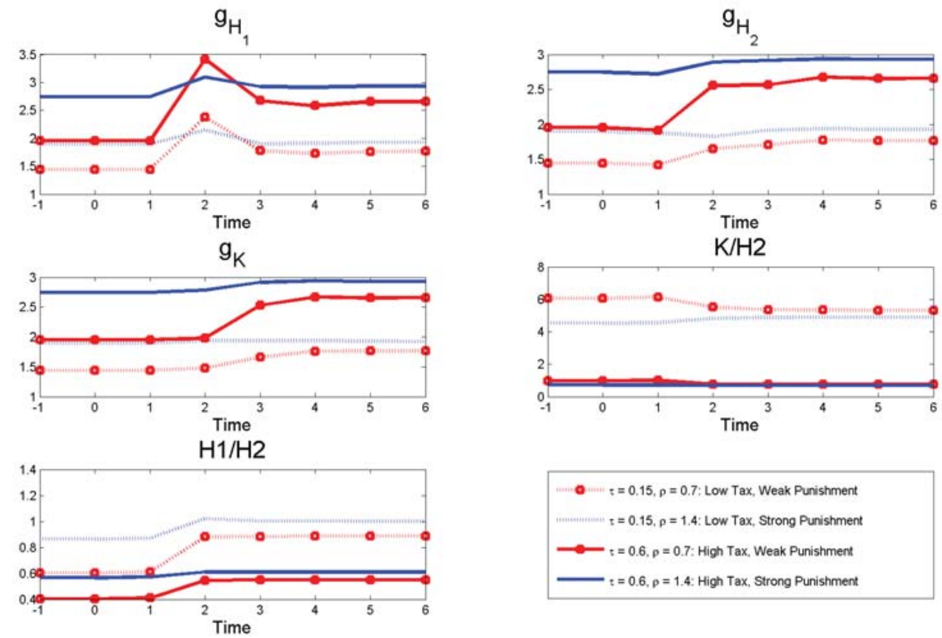

Figure 24: Transition Paths with Rising Teacher Wages

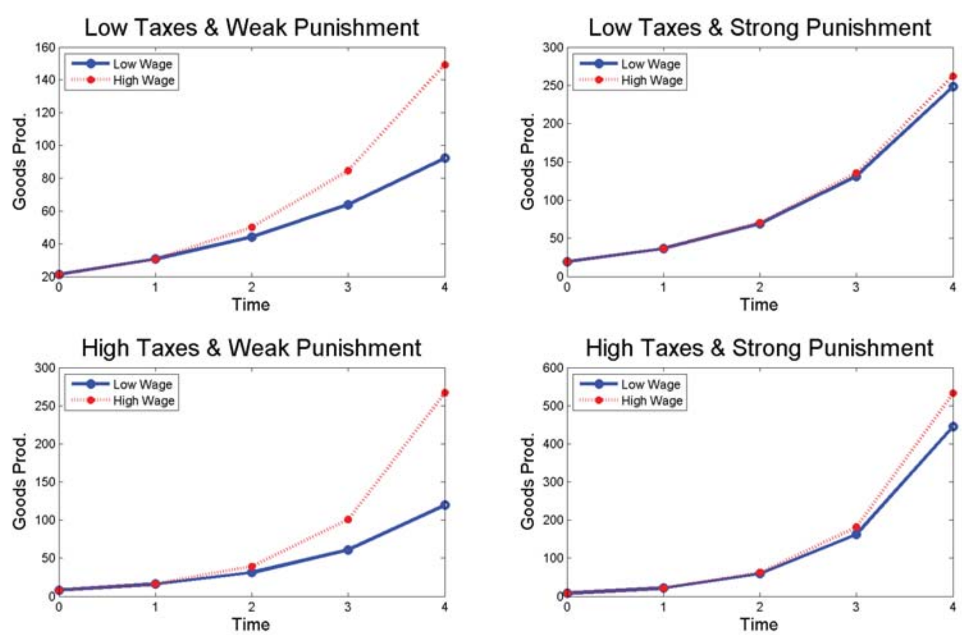

Figure 25: Levels of Goods Production at Transition when Teacher Wage Rises

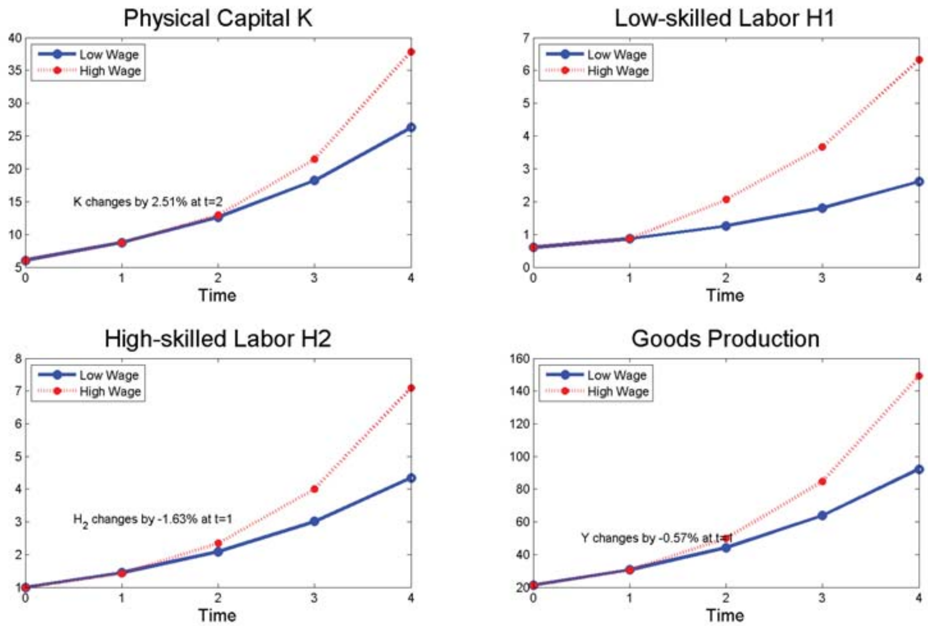

Figure 26: Change in Levels at Transition; Regime One: Low Tax and Weak Punishment.

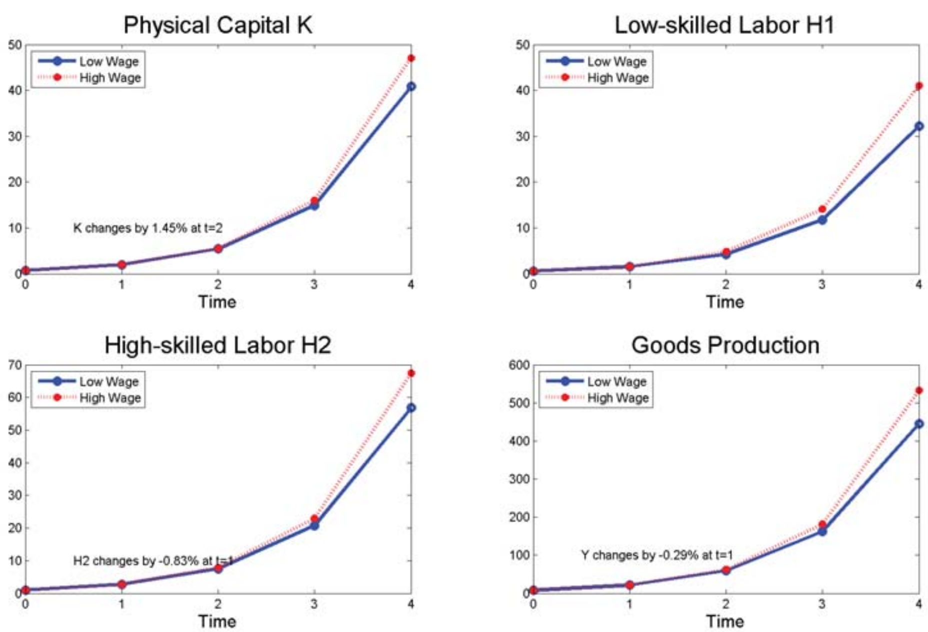

Figure 27: Change in Levels at Transition; Regime Four: High Tax and Strong Punishment.

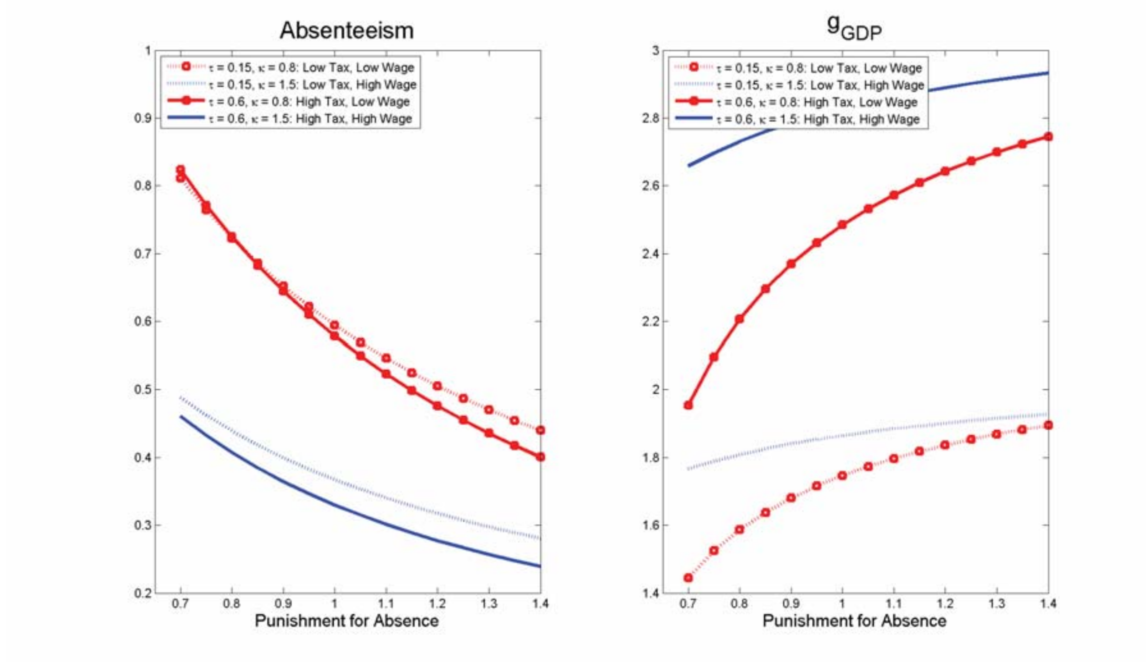

Figure 28: Balanced Growth Paths with Stronger Punishment on Absence

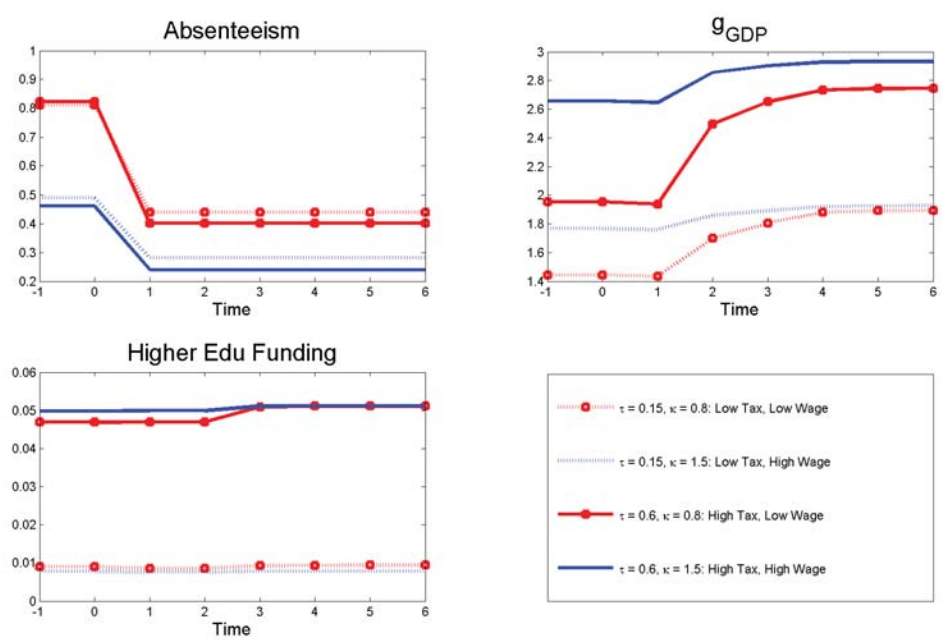

Figure 29: Transition Paths with Stronger Punishment on Absence

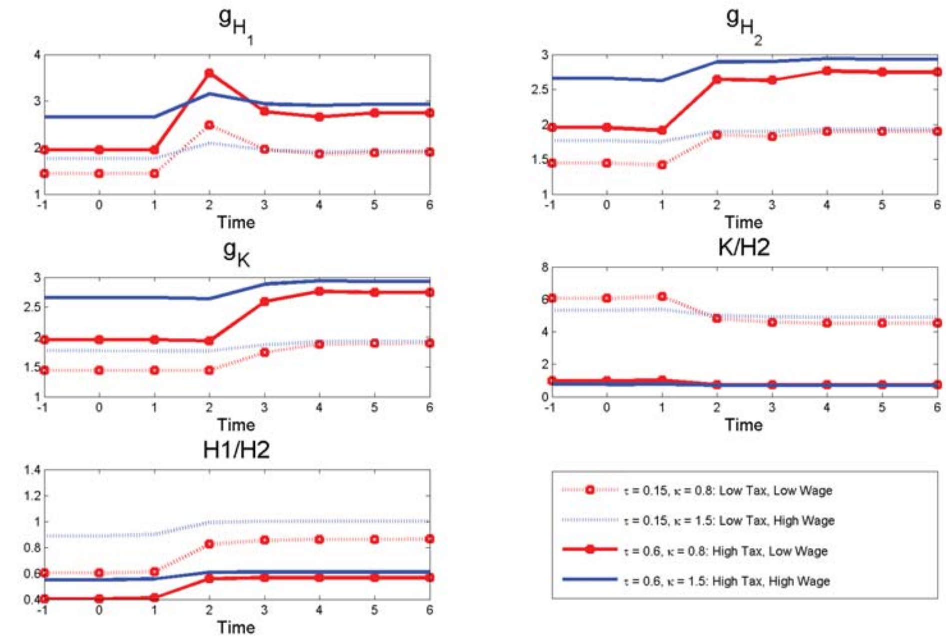

Figure 30: Transition Paths with Stronger Punishment on Absence

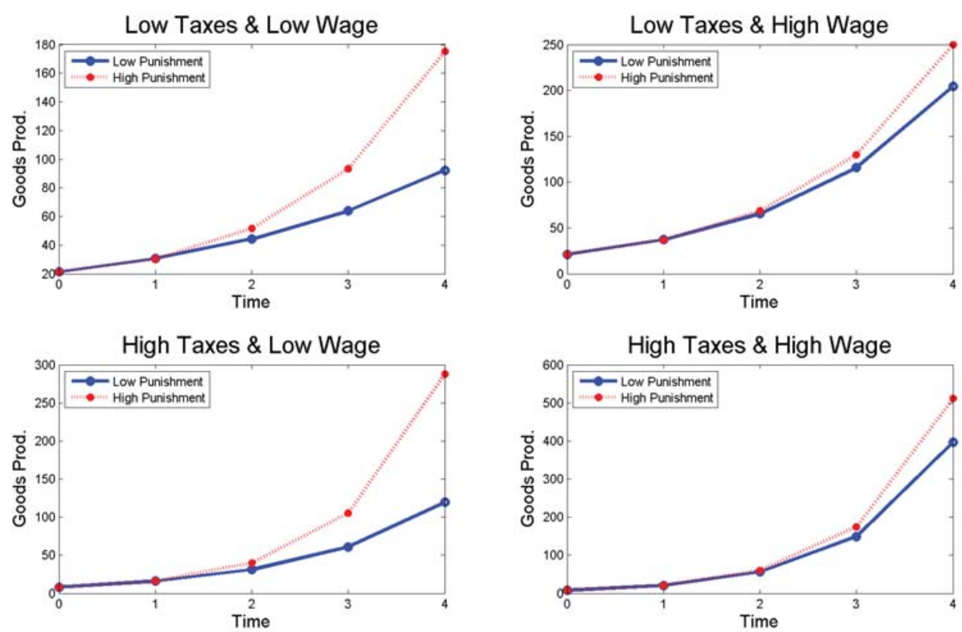

Figure 31: Levels of Goods Production at Transition when Punishment Changes

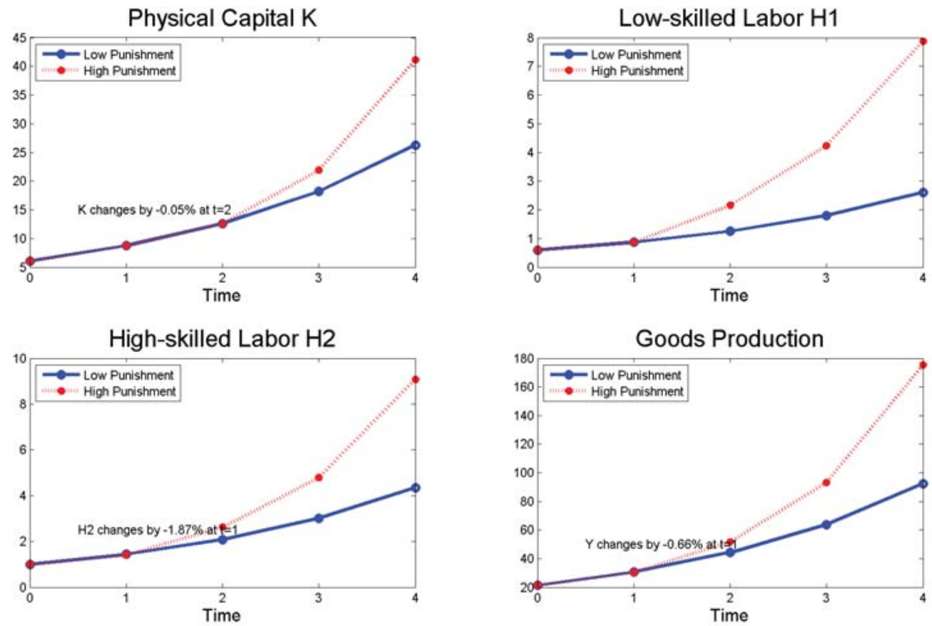

Figure 32: Change in Levels at Transition; Regime One: Low Tax and Low Wage.

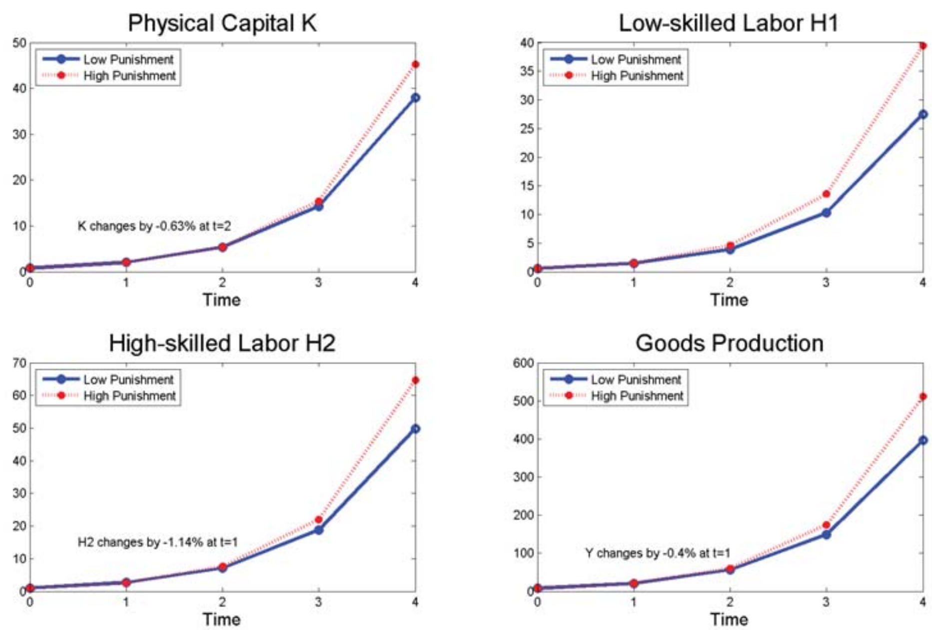

Figure 33: Change in Levels at Transition; Regime Four: High Tax and High Wage.

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EDUCATION

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RESEARCH SPECIALIZATION

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RESEARCH EXPERIENCE

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  January 2008–June 2009

TEACHING EXPERIENCE

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- Statistical Analysis for Business and Economics — Spring 2010
- Principles of Macroeconomics — Fall 2009
- Statistical Analysis for Business and Economics — Summer 2009
- Statistical Analysis for Business and Economics — Summer 2008
- Principles of Macroeconomics — Fall 2007
- Principles of Macroeconomics — Summer 2007

<u>Teaching Assistant</u> (Conducting Review Sessions and Discussions; Grading)

- Principles of Macroeconomics — Spring 2007
- Principles of Macroeconomics — Fall 2006

- Principles of Macroeconomics — Spring 2006

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- Intermediate Macroeconomics — Summer 2006
- Principles of Macroeconomics — Fall 2005

WORKING PAPERS

- Human Capital, Return Migration and Rural Entrepreneurship in China
- Migration and Rural Non-farm Business in China: A Dynamic Bivariate Probit Analysis
- Teacher Absenteeism, Human Capital, and Growth (with Gerhard Glomm)

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- Frank T. Bachmura Award for Excellent Research in Development Economics, Indiana University, 2010
- Alumni Associate Instructor Award for Excellence in Teaching, Indiana University, 2010
- Full Assistantship, Indiana University, 2005–Present
- College of Arts and Sciences Graduate Fellowship, Indiana University, 2005
- National Scholarship for University Students, China, 2004

CONFERENCES

- Present in the *6th Annual Workshop in Macroeconomic Research in Liberal Arts Colleges*, August 2010 (upcoming)
- Presented in the *85th Annual Conference of Western Economic Association International*, Portland, June 2010
- Presented in the 2009 *Chinese Economists Society Annual Conference*, China, June 2009
- Presented in the *Ninth Annual Missouri Economics Conference*, University of Missouri-Columbia and Federal Reserve Bank of St. Louis, March 2009
- Presented in the *National Conference for Academic Disciplines*, University of Nevada Las Vegas, 2009
- Presented in the *Jordan River Conference*, Indiana University, April 2008

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